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Weave Construction and Cloth Analysis

Glossary of Weaves—Elementary Textile Designing—Analysis of Cotton Fabrics—Analysis of Woolen and Worsted Fabrics—Twill Weaves and Derivatives—Satin and Other Weaves—Combination Weaves—Construction of Spot Weaves—Weaves for Backed Cotton Fabrics.

By

I. C. S. STAFF

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Scranton, Pennsylvania

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PREFACE

In the preparation of the volumes of the International Library of Technology that deal with textile manufacturing, the desire of persons identified with the industry for pertinent and exact technical information has been constantly kept in mind. Undoubtedly, these texts will be of great value to all who are in any way connected with, or interested in, the manufacture of textiles, but the detailed instruction has been prepared specifically for teaching those who actually are engaged in the spinning of yarns and the designing and weaving of fabrics in textile mills. It is hoped, therefore, that these books will not only prove useful to busy mill executives and others for ready reference, but that they will also be of exceeding value for study to all who are actively engaged in the practical work of textile establishments.

As reference works, these volumes should enable many perplexing problems to be solved quickly and in an authoritative manner. As textbooks for study, they should serve to impart an accurate knowledge of manufacturing operations and processes to those who are most vitally concerned. In the latter case, the library will prove most helpful to the many textile workers who wish to improve their understanding of the machines and processes incident to operations included in the practical work of the department of the mill or branch of the textile industry with which they are identified. Moreover, many persons engaged in textile work are unfamiliar with any phase of textile manufacturing except the work of the department of the mill in which they are employed. Thus, those who are engaged in weaving may know nothing of spinning, carders may be unfamiliar with the work of spinners and weavers, superintendents may have a practical knowledge of only a single department, and so on. To all such, the study of textbooks relating to other branches of textile manufacturing has a distinct broadening influence that is exceedingly valuable to those in executive positions involving contacts with the work of a number of departments.

The technical information contained in these volumes is intensely practical, and the text has been carefully written so that facts and explanations may be readily grasped by those who

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are, or who are not, technically trained. A special effort has been made to treat all subjects completely from elementary to advanced stages, but explanations and descriptions have been made as concise as possible, consistent with a thorough treatment of the wide range of subjects. In describing a process, or the construction and operation of a machine, or method of performing necessary calculations, and the like, the subject is dealt with step by step so that there is no possibility of ambiguity. Illustrations have been used most generously, and have been employed whenever and wherever they serve to enhance the clearness of the text. Perspective drawings, plans, elevations, sections all have been employed and all have been drawn especially for these texts. Color has been employed in illustrations where it adds to the lucidity of explanations.

This textbook deals with the elementary, or basic, principles of textile designing and with the analysis of both cotton and woolen and worsted fabrics. The construction of twill weaves and their derivatives, of satin weaves and weaves derived from them, of combination weaves, of spot weaves, and of weaves for backed cotton fabrics is also the subject of exhaustive treatment. A glossary of 400 weaves, repeating on from 2 ends to 24 ends, that are frequently employed by textile designers is also included. That this volume is adequately illustrated, is borne out by the fact that it contains well over 600 illustrations, all of which have been prepared especially for this instruction.

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NOTE.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents, the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

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GLOSSARY OF WEAVES

Serial 501 Edition 1

INTRODUCTION

The weave, or method of interlacing the warp and filling yarns, is, in the majority of fabrics, of primary importance, since it not only determines the actual structure of the cloth, but also greatly affects its ultimate appearance. Thus, fabrics composed of warp and filling yarns of the same material and counts vary greatly in appearance if woven with a plain weave or with a twill weave, etc. In designing fabrics of various types and constructions, it frequently happens that difficulty is experienced in obtaining a suitable weave with which to construct the cloth. It is also of great advantage to the designer if, when designing a fabric, a weave can be selected from a number of weaves that will give the best result and is best suited to the type of fabric that it is desired to produce. The utility of a collection of the more common and valuable weaves used in textile designing, arranged and classified in a comprehensive manner, is therefore readily apparent. In this glossary, a large number of valuable weaves are given, classified according to the number of ends on which they are complete. Thus, in case a designer is laying out a fabric that it is desired shall be woven with a weave complete on 8 ends, a large number of weaves complete on this number of ends are available, from which a suitable weave may be selected. It will be understood that this collection of weaves does not contain every known weave, since it is possible to construct many thousands of different weaves; in fact, the number of weaves that may be

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made is unlimited. The collection of weaves given, however, is complete enough for all ordinary purposes and contains examples of those types in most frequent use and that are therefore of more particular importance. While in some cases it may be found that none of the weaves contained in the glossary exactly meet the requirements of a designer who wishes to produce a certain fabric, yet the weaves shown will often be of service in suggesting new ideas for the construction of a weave suitable for the cloth that it is desired to produce, or it may even be found that a slight alteration of some one of the weaves shown will so change its structure and the effect that it will produce in a fabric as to render it perfectly adapted to the purposes of the designer. The weaves given are numbered consecutively, and throughout the following Sections dealing with the various features of textile designing, frequent reference is made to them.

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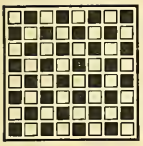
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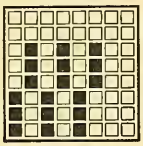
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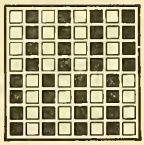
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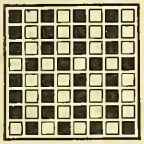
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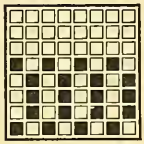
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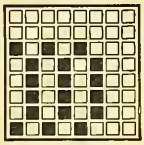
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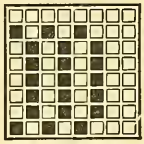
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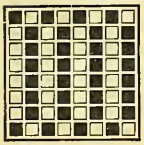
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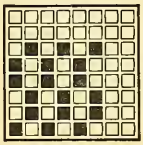
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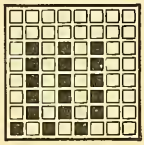
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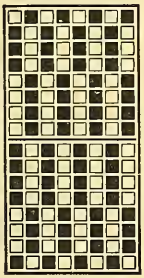
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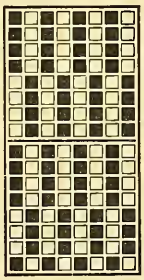
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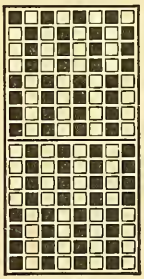
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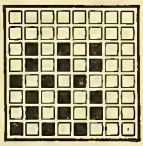
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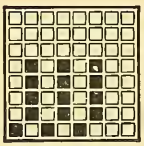
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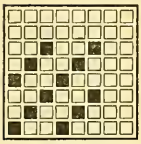
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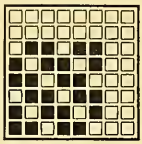
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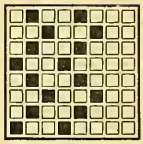
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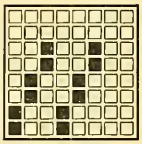
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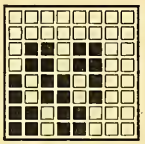
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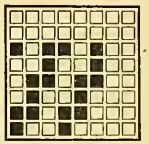
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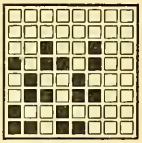
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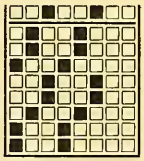
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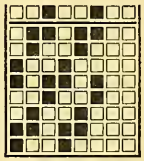
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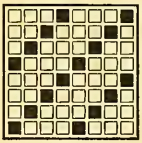
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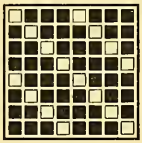
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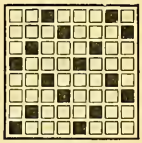
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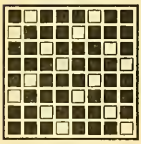
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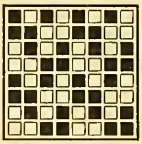
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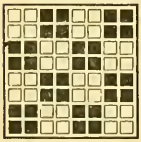
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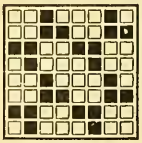
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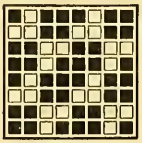
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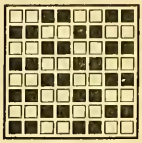
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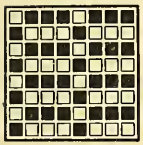
WEAVES COMPLETE ON 4 ENDS—(Continued)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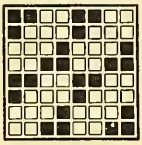
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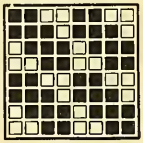
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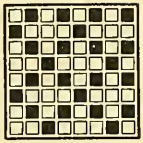
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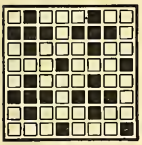
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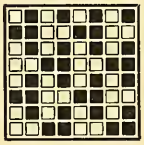
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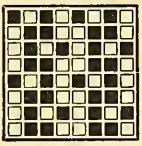
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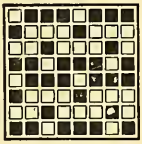
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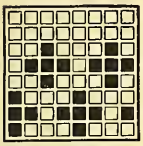
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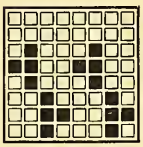
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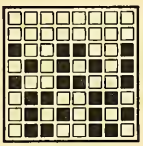
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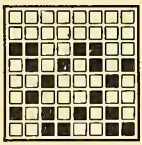
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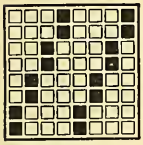
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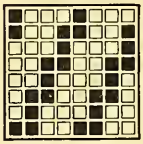
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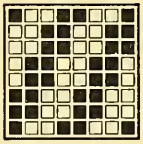
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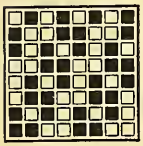
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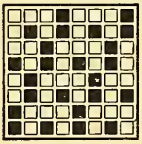
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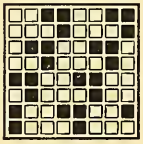
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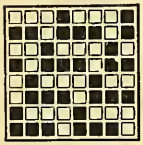
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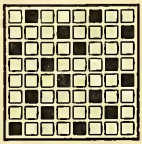
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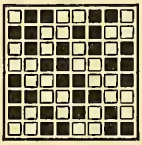
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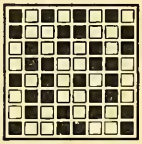
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WEAVES COMPLETE ON 4 ENDS—(Continued)

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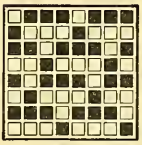
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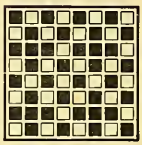
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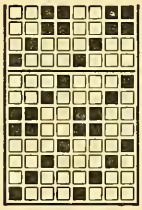
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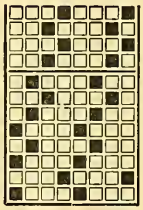
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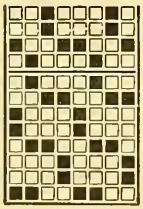
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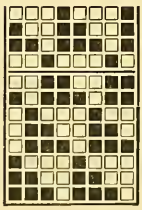
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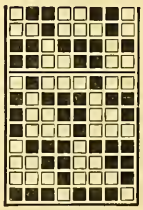
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WEAVES COMPLETE ON 5 ENDS

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WEAVES COMPLETE ON 5 ENDS—(Continued)

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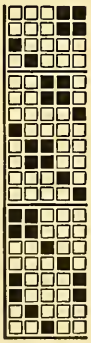
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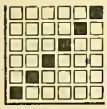
WEAVES COMPLETE ON 6 ENDS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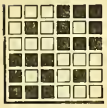
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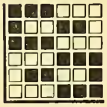
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WEAVES COMPLETE ON 6 ENDS—(Continued)

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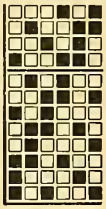
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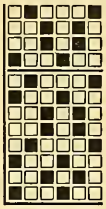
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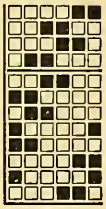
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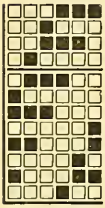
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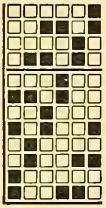
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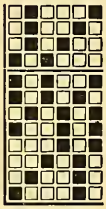
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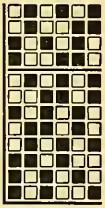
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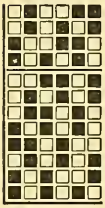
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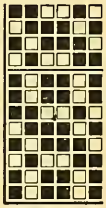
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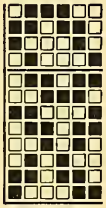
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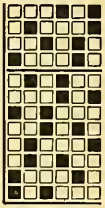
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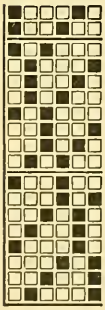
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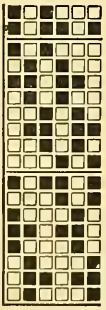
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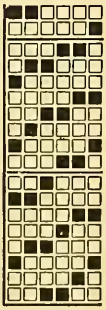
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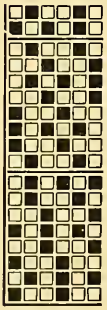
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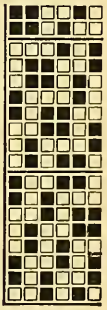
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WEAVES COMPLETE ON 7 ENDS

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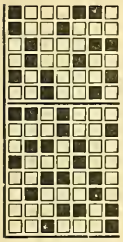
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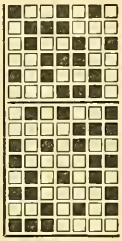
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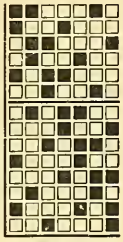
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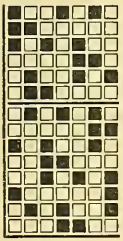
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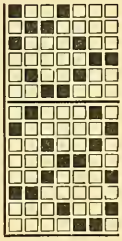
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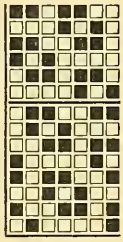
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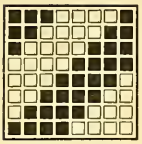
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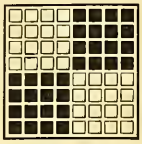
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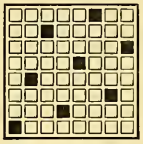
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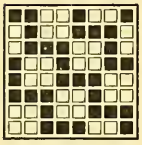
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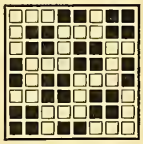
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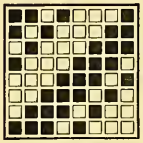
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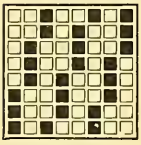
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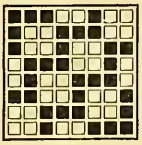
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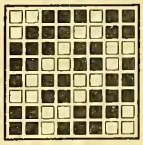
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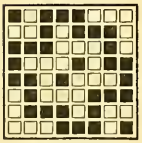
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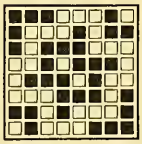
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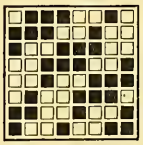
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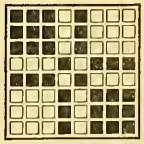
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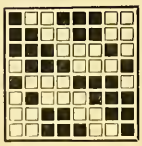
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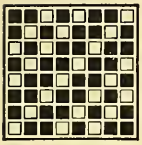

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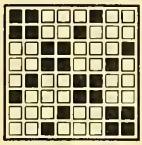

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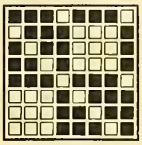

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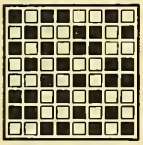

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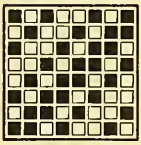

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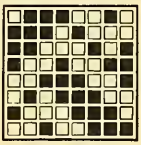

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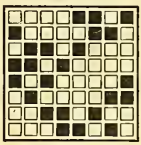

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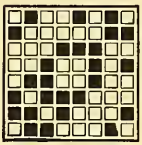

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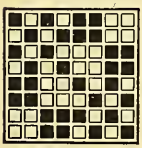

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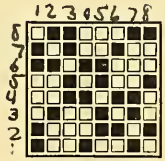

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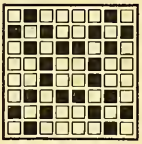

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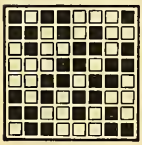

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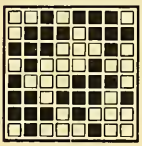

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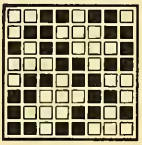

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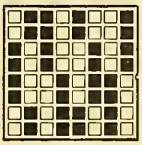

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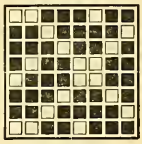
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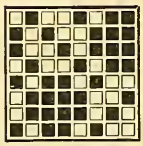
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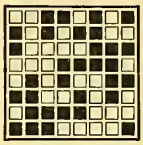
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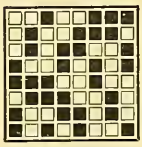
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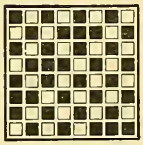
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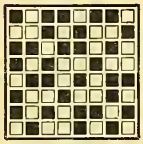
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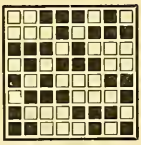
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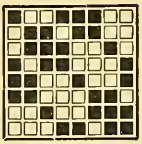
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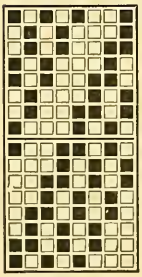
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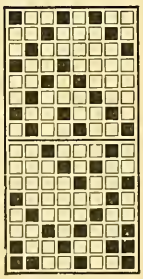
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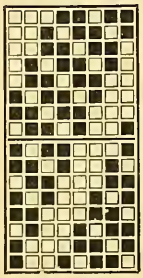
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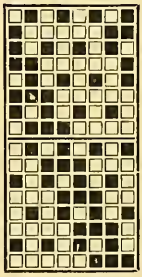
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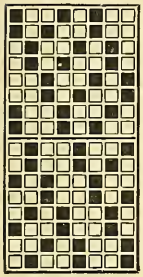
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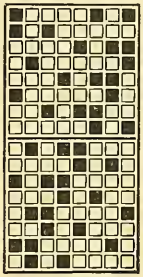
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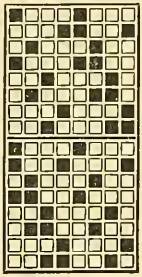
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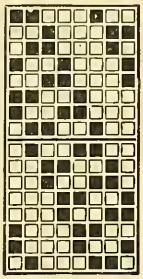
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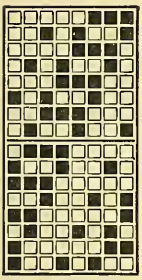
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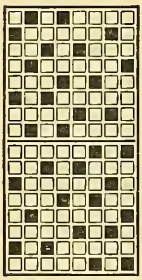
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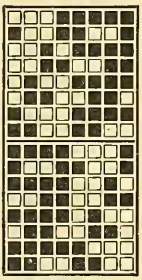
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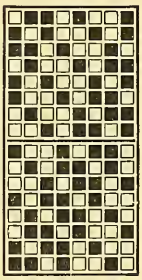
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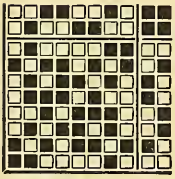
WEAVES COMPLETE ON 10 ENDS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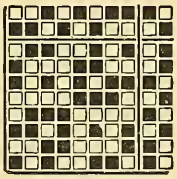
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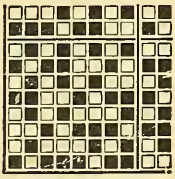
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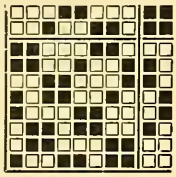

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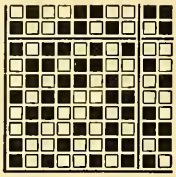

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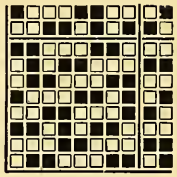

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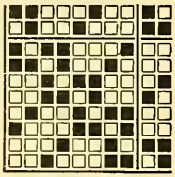

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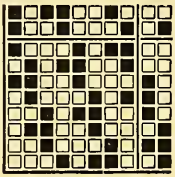

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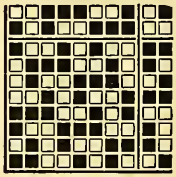

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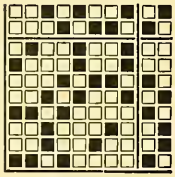

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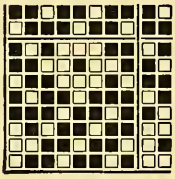

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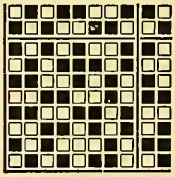

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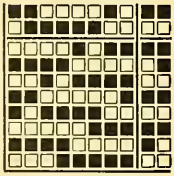

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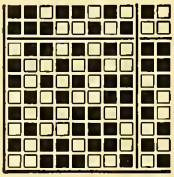

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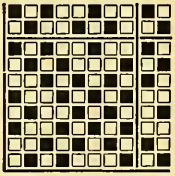

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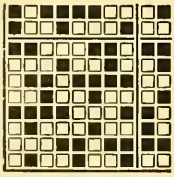

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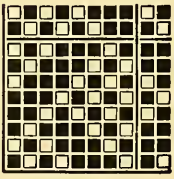

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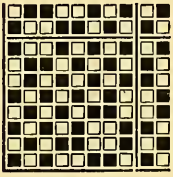

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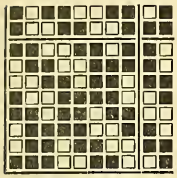
New Bedford Textile Institute
New Bedford, Mass.

WEAVES COMPLETE ON 10 ENDS—(Continued)



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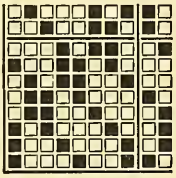

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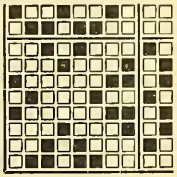

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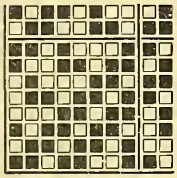

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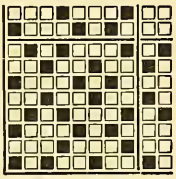

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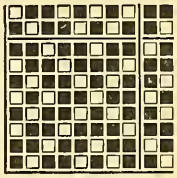

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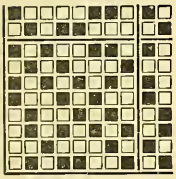

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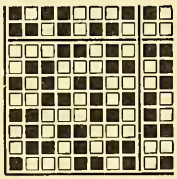

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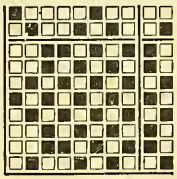

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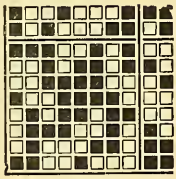

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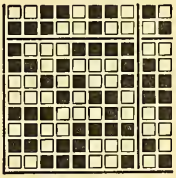

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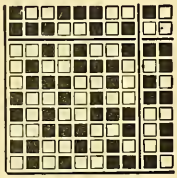

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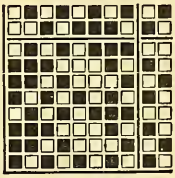

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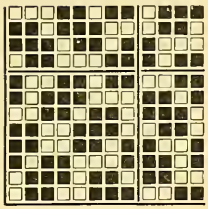
WEAVES COMPLETE ON 12 ENDS



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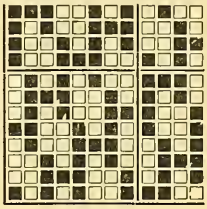

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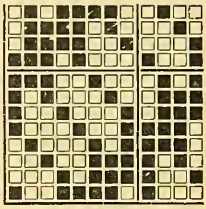

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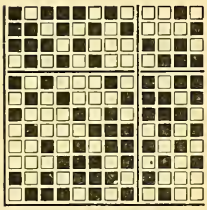

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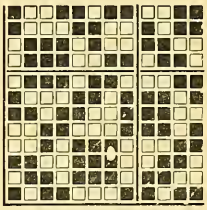

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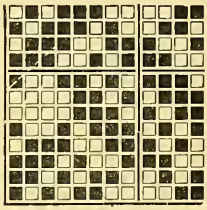

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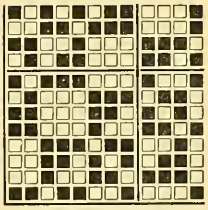

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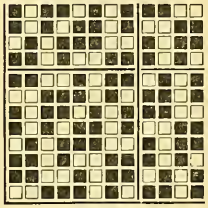

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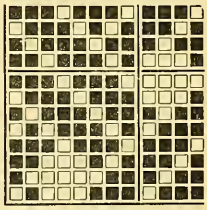

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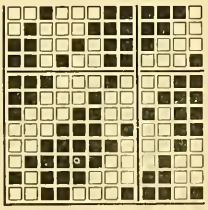

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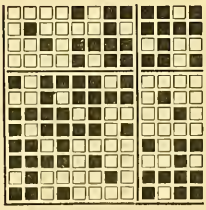

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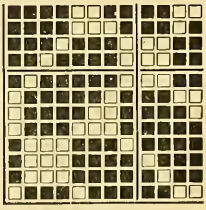

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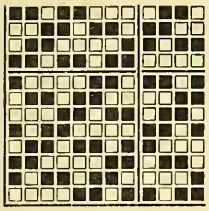
WEAVES COMPLETE ON 12 ENDS—(Continued)



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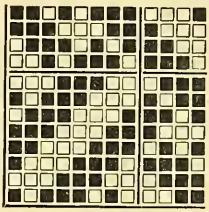

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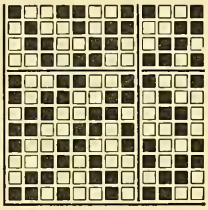

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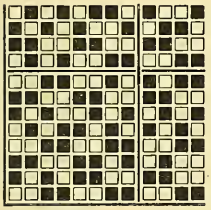

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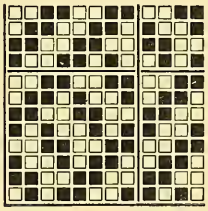

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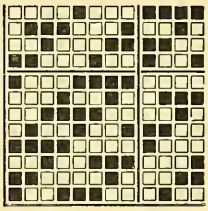

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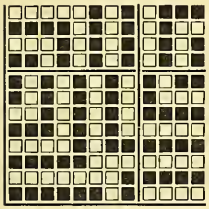

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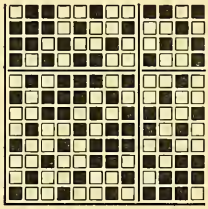

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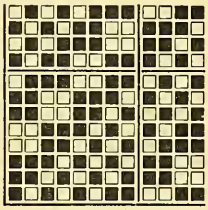

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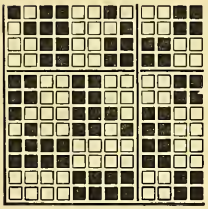

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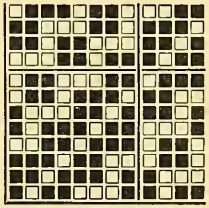

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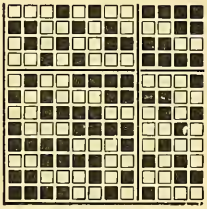

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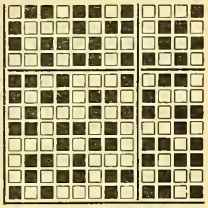
WEAVES COMPLETE ON 12 ENDS—(Continued)



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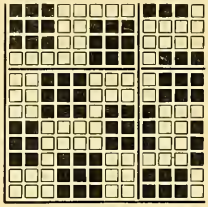

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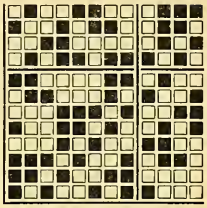

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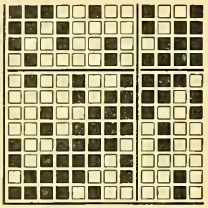

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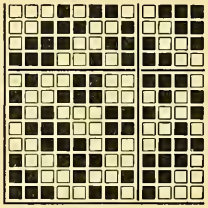

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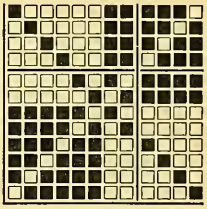

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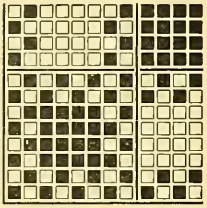

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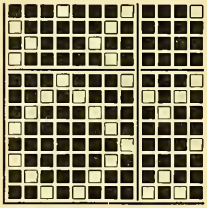

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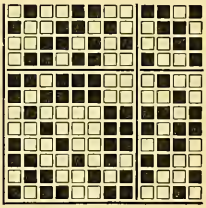

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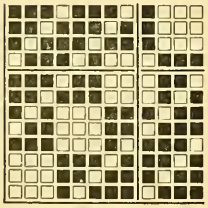

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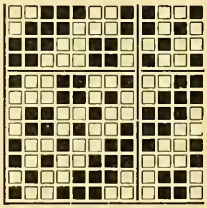

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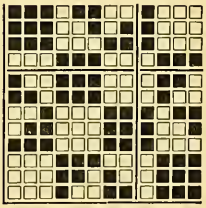

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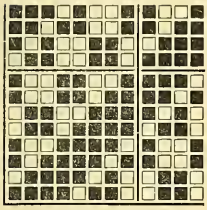
WEAVES COMPLETE ON 12 ENDS—(Continued)



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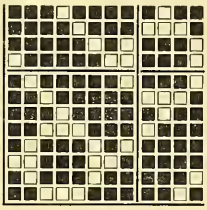

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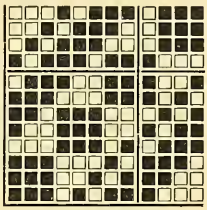

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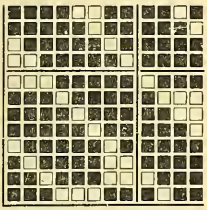

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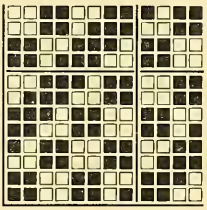

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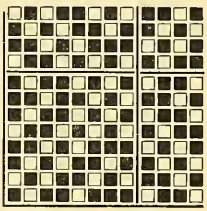

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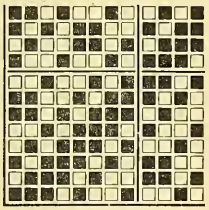

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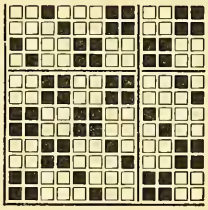

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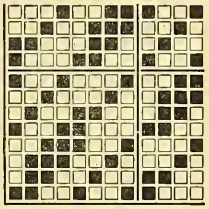

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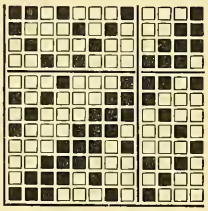

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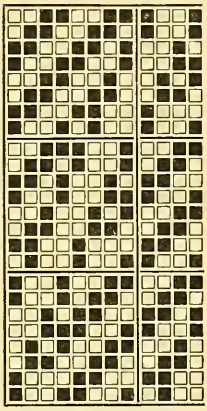
WEAVES COMPLETE ON 12 ENDS—(Continued)



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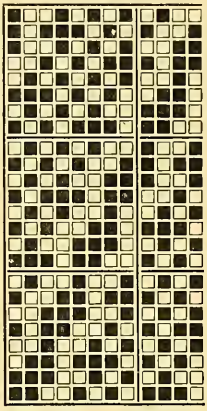

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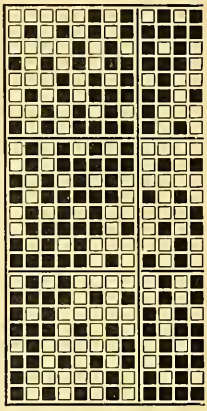

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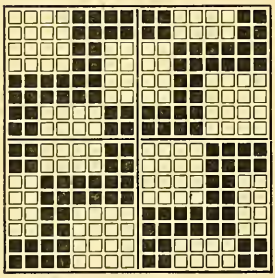
WEAVES COMPLETE ON 16 ENDS



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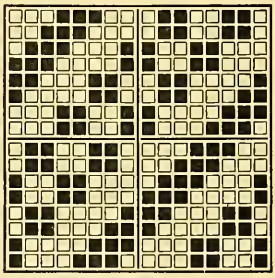

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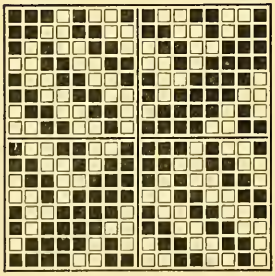

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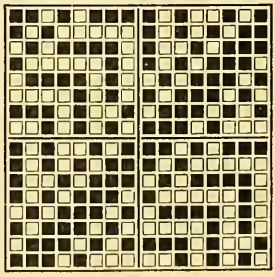

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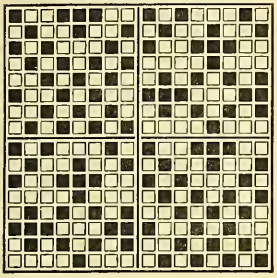
WEAVES COMPLETE ON 16 ENDS—(Continued)



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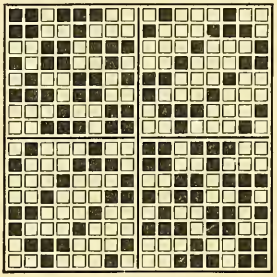

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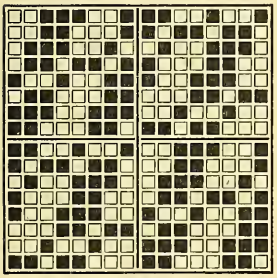

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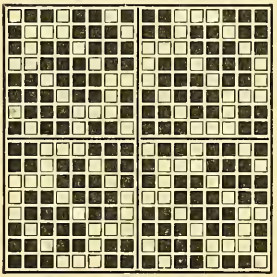

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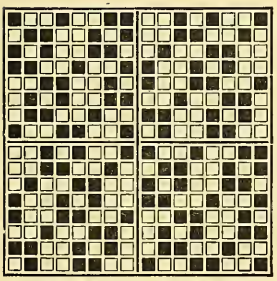

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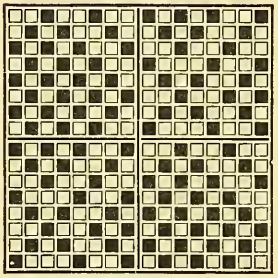

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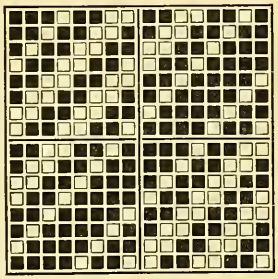
WEAVES COMPLETE ON 16 ENDS—(Continued)



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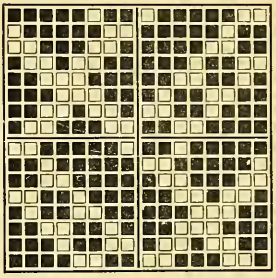

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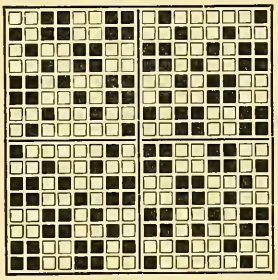

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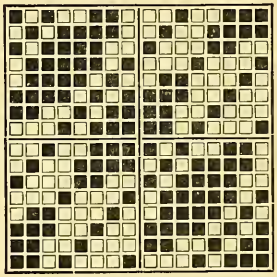

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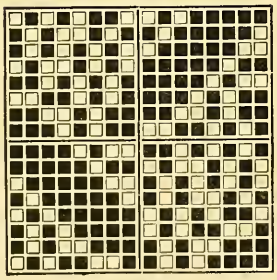

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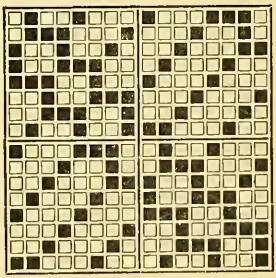

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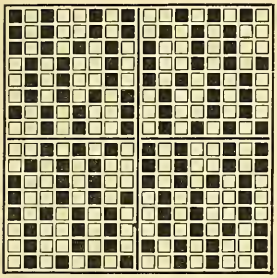
WEAVES COMPLETE ON 16 ENDS—(Continued)



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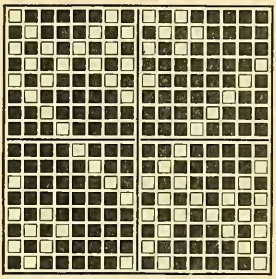

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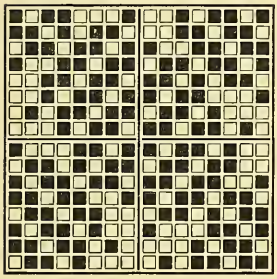

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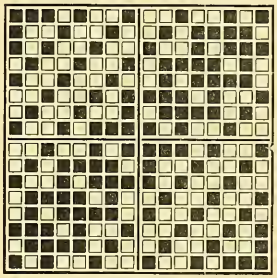

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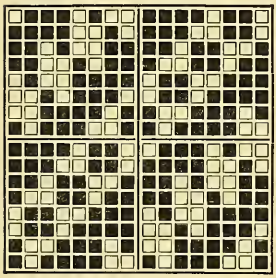

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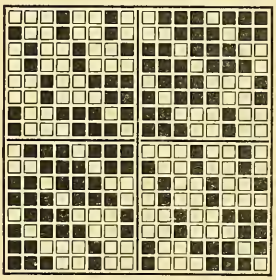

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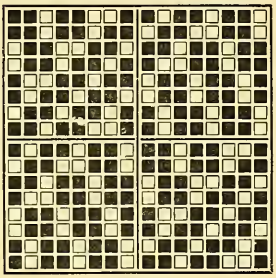
WEAVES COMPLETE ON 16 ENDS—(Continued)



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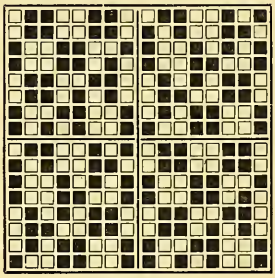

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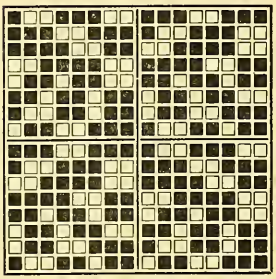

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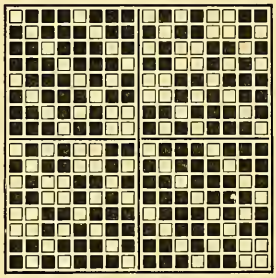

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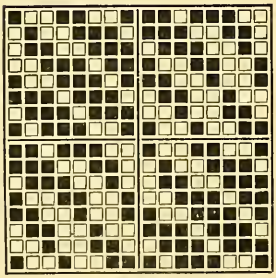

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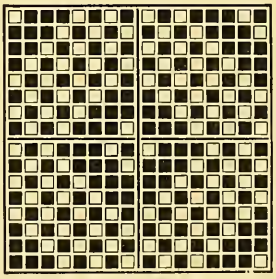

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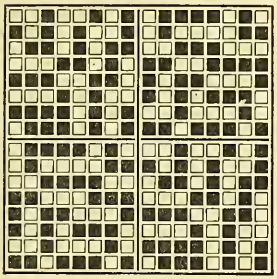

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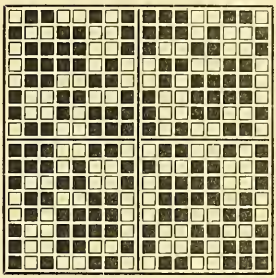

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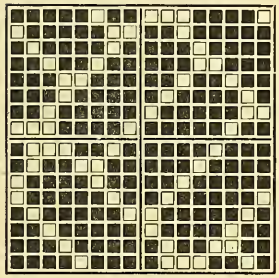

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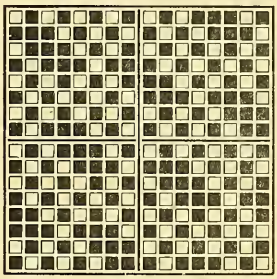

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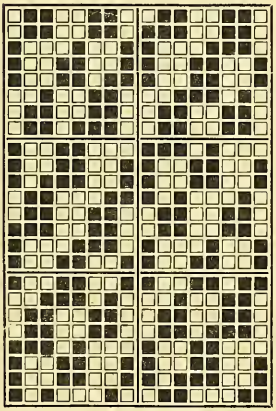

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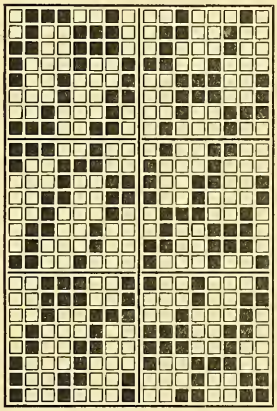

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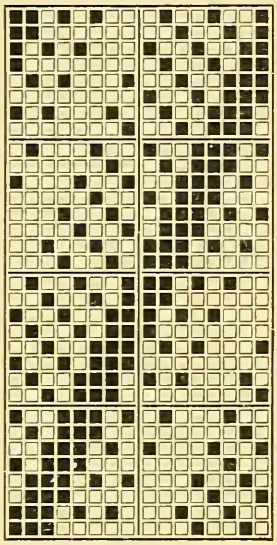

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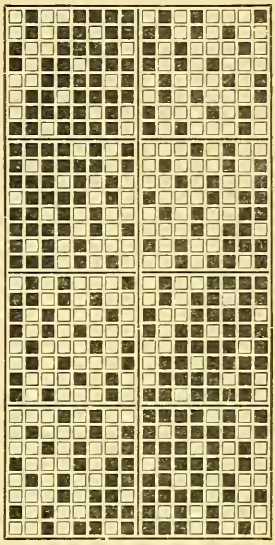

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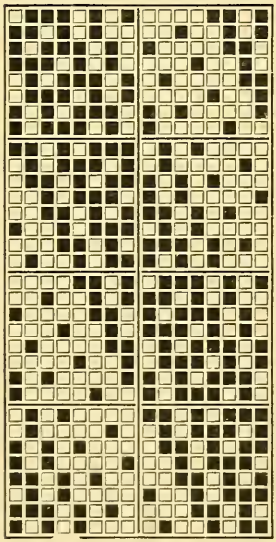

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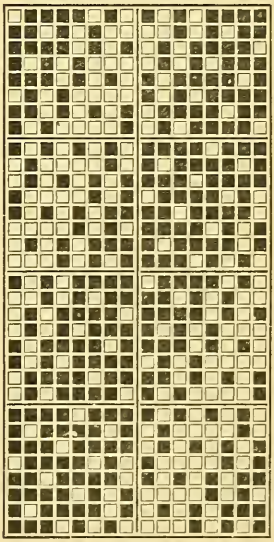

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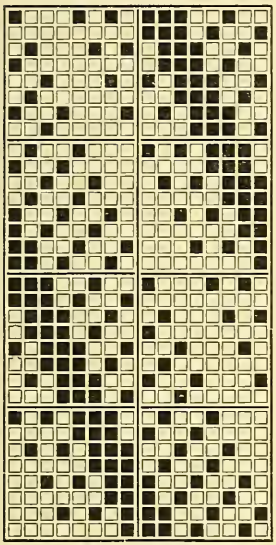

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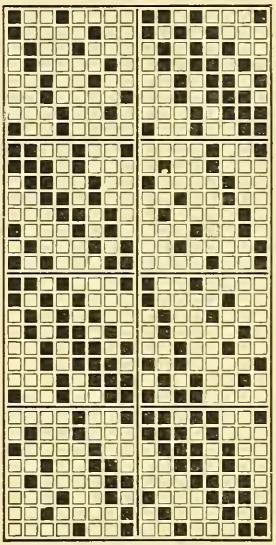

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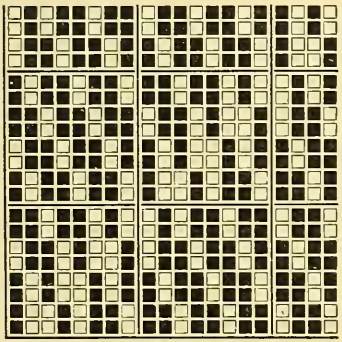

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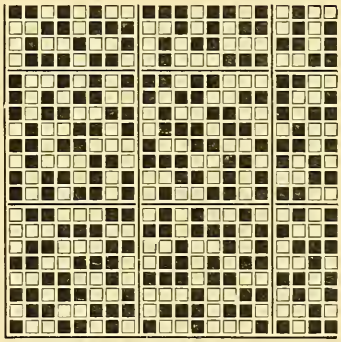

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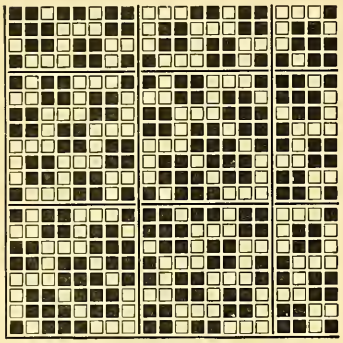

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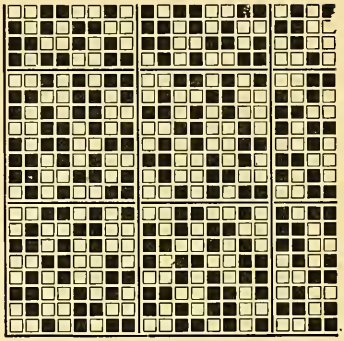

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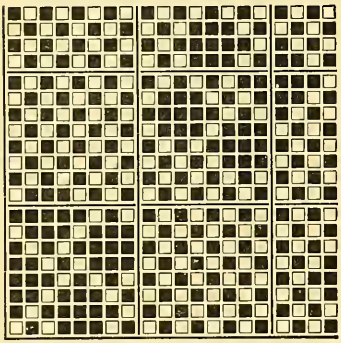

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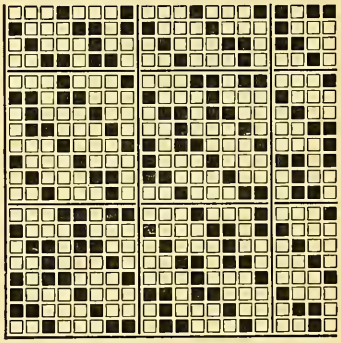

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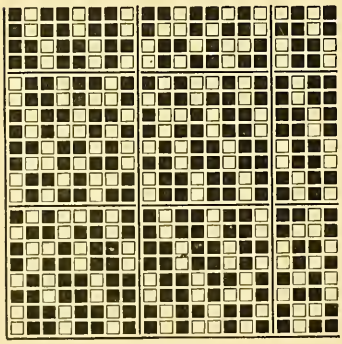

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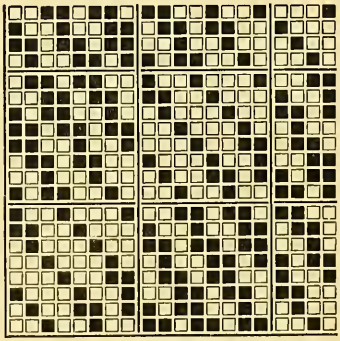

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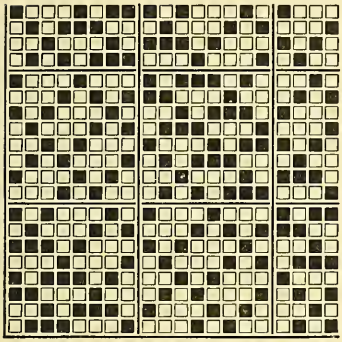

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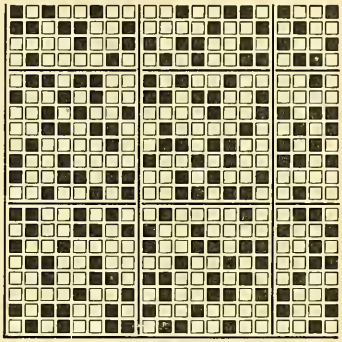

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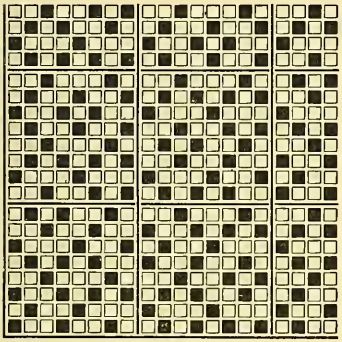

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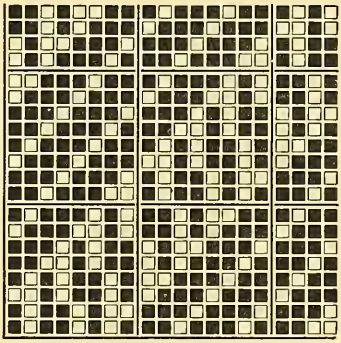

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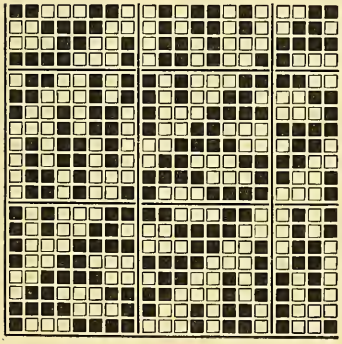

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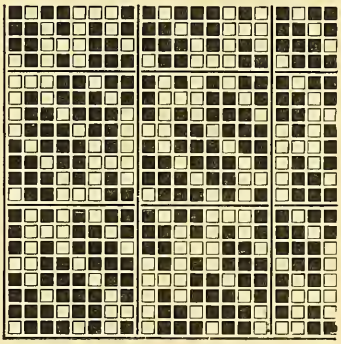

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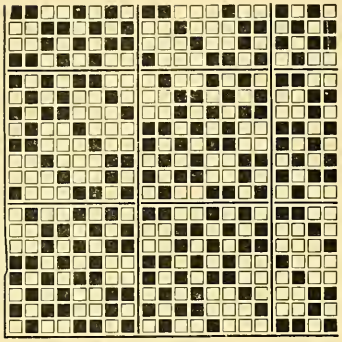

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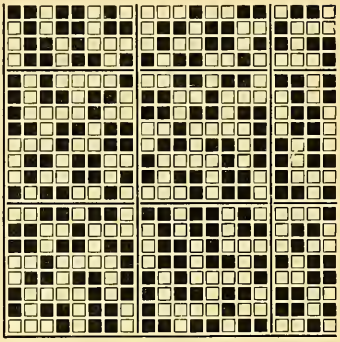

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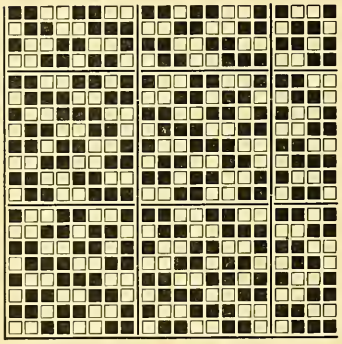

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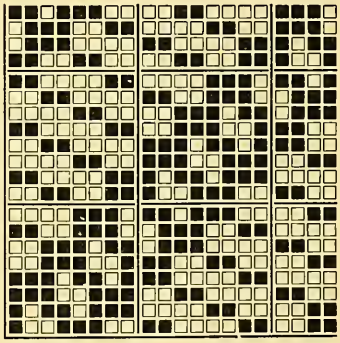

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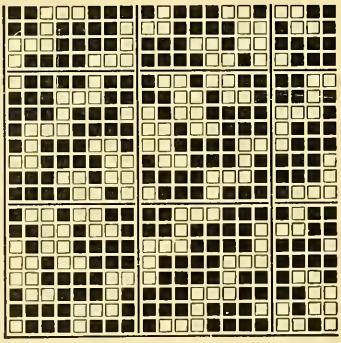

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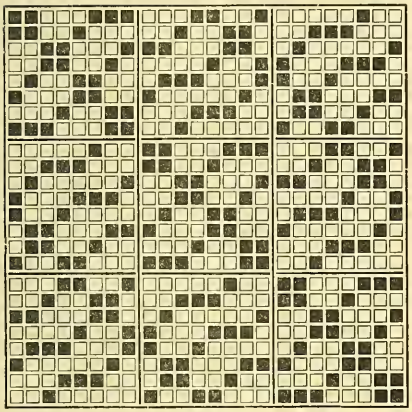

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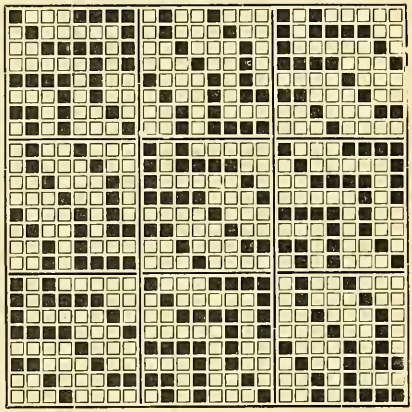

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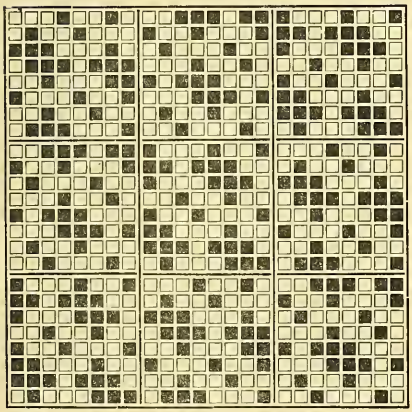

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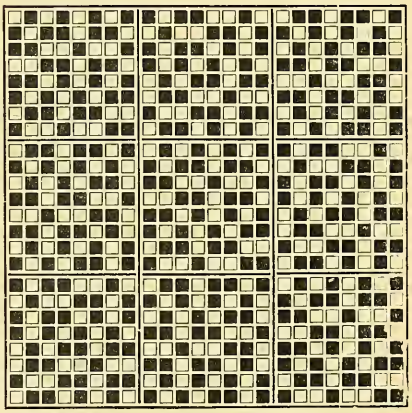

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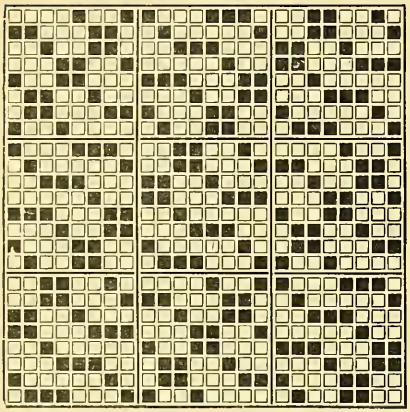

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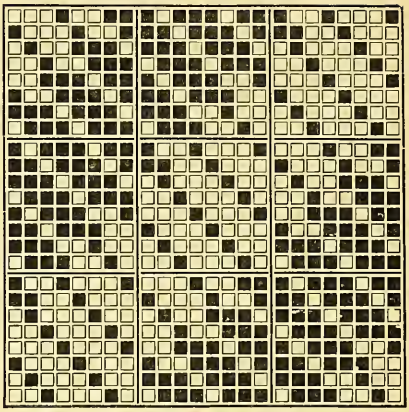

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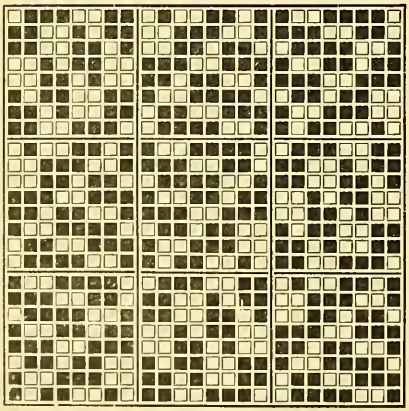

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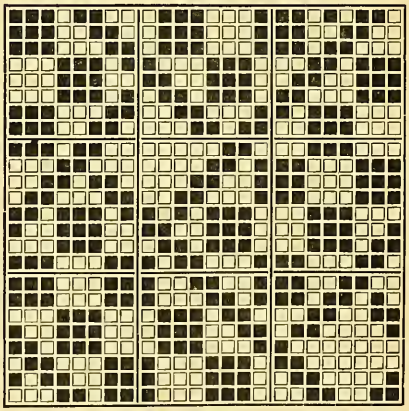

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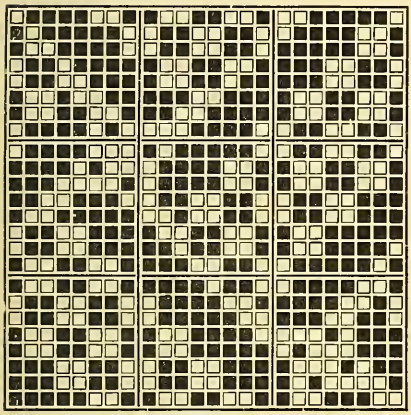

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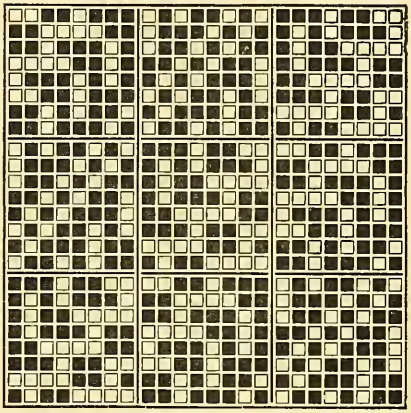

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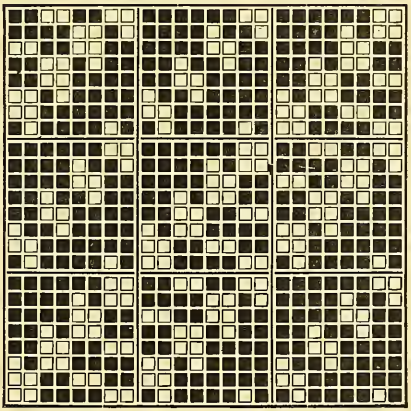

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ELEMENTARY TEXTILE DESIGNING

Serial 502 Edition 1

FUNDAMENTAL PRINCIPLES OF DESIGNING

INTRODUCTION

1. In the manufacture of textile fabrics, other than plain, standard goods, no branch of the business is more important than that of **designing**, nor does anything affect the desirability and selling qualities of a fabric more than the design. The material may be costly, the yarn perfect, and the weaving and finishing well executed, but if the design is not well conceived, or is not adapted to the purpose for which the cloth is intended, the fabric will be inferior. The designing of a textile fabric is an operation peculiar to itself and somewhat foreign to the general conception of the term designing, in that the actual construction of the fabric must be considered in order to obtain the desired effect, or design, on its face. In order that the best methods of manufacturing any class of goods may be intelligently understood, it is first of all essential to acquire a thorough knowledge of woven fabrics, since if the results obtained, or in other words the finished cloths, are not understood, it is unreasonable to suppose that the reasons for the processes through which the yarns pass before becoming cloth can be intelligently comprehended. The person who can take a small sample of cloth and reproduce it in the loom or who can originate a

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design of merit with only the necessary yarns and mechanisms with which to work, even if this work is not in his direct line, has a great advantage over a person who cannot. Designing may be said to be as old as weaving, since no cloth can be produced unless the manner in which the ends are drawn through the harnesses, the order of raising the harnesses, and the order of interlacing these ends with the filling are known.

Cloth analysis, or the process of finding the method of construction employed in a fabric, and designing, which strictly speaking, is the process of originating new fabrics, are studies that are closely allied, and the benefit derived from a close study of the structure of the various fabrics frequently met with cannot be overestimated.

WEAVE

2. Construction of Fabrics.—All woven fabrics are constructed of two series of yarns; namely, the *warp*, which is the system of parallel threads running lengthwise of the goods, and the *filling*, which is the system of parallel threads running across the cloth at right angles to the warp. A single thread of the warp is known as a *warp end*, or simply an *end*, and a single thread of the filling is known as a *pick*. By the weaving process the picks of the filling are interlaced with the ends of the warp so as to produce a woven fabric of a texture depending, to a great extent, on the method of interlacing.

3. Plain Weave.—The simplest method of interlacing the warp and filling is by that system known as *plain weave*. Fig. 1 is a diagrammatic view of a plain woven fabric, in which the threads shown in a vertical position are the warp ends, while those running from side to side are the picks of filling. If this diagram is examined closely, it will be noticed that one pick of filling is over all the odd-numbered ends of the warp and under all the even-numbered ends, while the next pick of filling interlaces with the warp ends in reverse order. This method of interlacing the warp and

filling is the simplest that can be devised, and is therefore called the **plain weave.**

It should be understood, however, that the interlacing of the warp and filling is not the same in all cloths; in fact, it is by changing the manner of this interlacing that different effects are formed.

4. Design Paper.—Since there are many methods of interlacing the warp and filling, some system must be employed to represent these methods, or *weaves*, on paper.

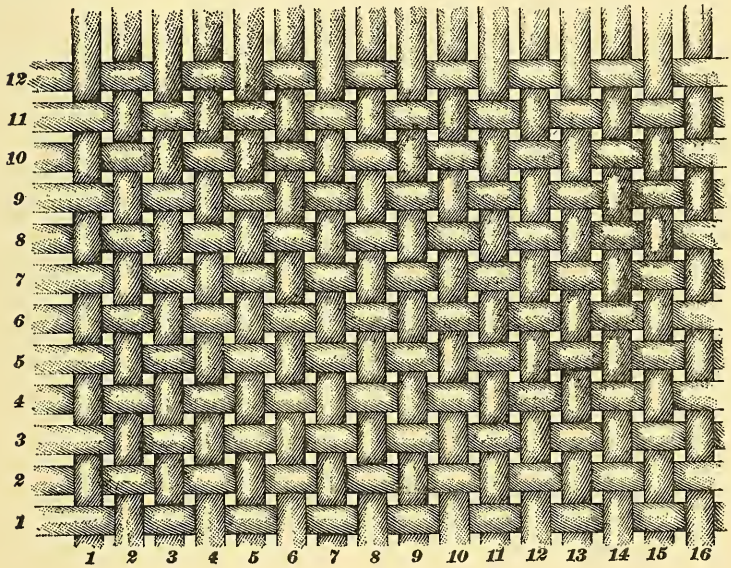


FIG. 1

The one universally used employs an especially ruled paper, shown in Fig. 2, known as **design paper.** It is made in several styles but the kind commonly used is shown at (*a*); the others are used in special cases. The common form of design paper is divided by heavy lines into blocks of eight rows of squares each way. Each vertical row of squares of the design paper represents a warp end, and each horizontal row, that is, those that run from side to side, represents a **pick of filling.** It should be thoroughly understood that it

is not the lines but the rows of squares enclosed by these lines that represent the ends and picks; thus in Fig. 2 (*a*) there are 8 ends and 8 picks represented in each part marked

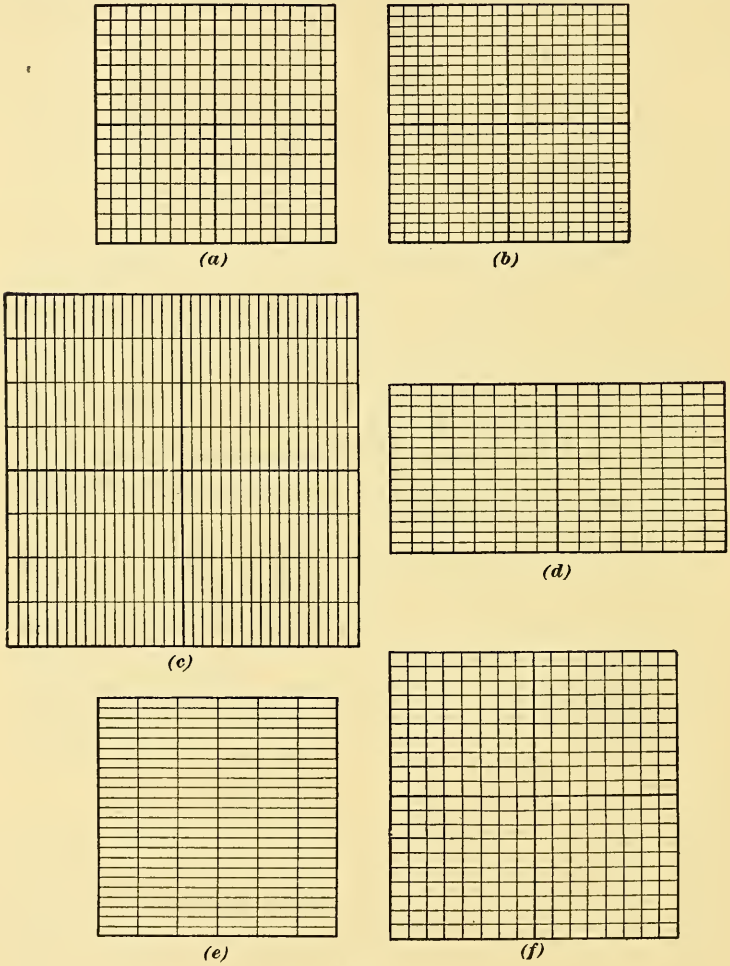


FIG. 2

off by the heavy lines. This is the method of designating different design paper; that is, by giving the number of ends and picks that are shown in the square marked off by the

heavy lines. In speaking of design paper the number of ends represented is always given first, followed by the number of picks represented. Thus (*a*) is called 8×8 design paper; (*b*) is 8×12; (*c*) is 18×4; (*d*) is 8×16; (*e*) is 6×24; and (*f*) is 8×10.

METHOD OF INDICATING A WEAVE ON DESIGN PAPER

5. The interlacing of the warp and filling, or the weave, is indicated by marking or filling in certain squares of the design paper while others are left blank. When a square is marked, it indicates that the warp end represented by that vertical row of squares is lifted at that point and that the pick of filling represented by the horizontal row of squares is underneath the warp end; for instance, if the square on the first end and first pick is marked, it indicates that the first end is raised over the first pick. When a square is left blank, it indicates that the warp end represented by that vertical row of squares is lowered at that point and that the pick of filling represented by that horizontal row of squares is over the warp end; for instance, if the square on the first end and first pick is left blank it indicates that the first end is lowered under the first pick. The fact that marked squares always mean warp up and blank squares filling up, should be firmly fixed in mind.

The warp ends are drawn through harnesses, so that when a harness is raised the warp ends drawn through it are raised and lifted over the filling; whereas, when a harness is lowered the warp ends drawn through it are depressed under the filling. Consequently, whenever a square on the design paper is filled in, it shows that the harness through which that end is drawn is lifted; and, on the other hand, when a square is left blank, it shows that the harness through which that warp end is drawn is lowered.

6. The representation on design paper of the interlacing of the warp and filling is known as the **weave.** Fig. 3 is a diagrammatic view of a cloth woven with the plain weave and also illustrates the method of representing the weave on design paper. Dealing first with (*a*) and (*b*) only, (*a*) shows

the way the ends and picks of the cloth are interlaced, while (*b*) shows the weave.

It must constantly be borne in mind that each vertical row of squares represents a warp end, while each horizontal row represents a pick of filling. The lines drawn from (*a*) to (*b*) show which warp end each vertical row of squares represents; the ends are numbered *1*, *2*, *3*, *4*, *5*, and *6* at the bottom.

By following the ends from (*a*) to (*b*), it will be seen that when they are up, as shown in (*a*), the corresponding squares in (*b*) are filled in, and on the other hand when the ends are down, the corresponding squares in (*b*) are left blank. Following the first end, it will be noticed that, starting at the bottom of (*a*), this end is over the first pick *a*; therefore, the first square at the bottom of the row of squares representing this end, as shown in (*b*), is filled in. Continuing with this same end, it will be seen that it is under the next pick *b*; therefore, in (*b*) the next square above the one previously marked will be left blank. Still continuing with this end, it will be seen that it is over the next pick *c*; therefore, the next square above in (*b*) is filled in. The end now passes under the next pick *d* in (*a*) and is shown by leaving the corresponding square in (*b*) blank. Following the next end *2* in the same manner, it will be seen that it is under the pick *a*, over *b*, under *c*, and over *d*. If the

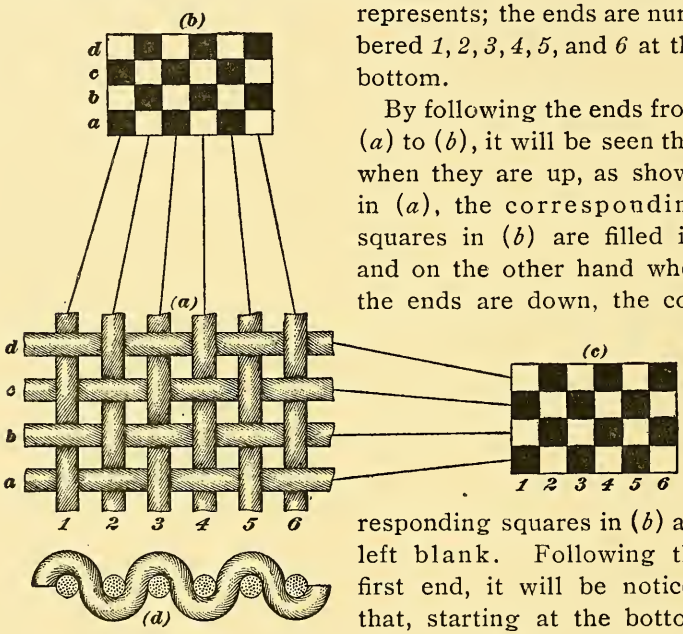


FIG. 3

vertical row of squares, in (*b*), that represents this end is now examined, it will be seen that wherever this end is up, the square is filled in, and wherever it is down, the square is left blank. Thus, the weave is shown in (*b*), and if each end is examined in the same manner it will be seen that the interlacing of each end in (*a*) is correctly shown in (*b*).

It should be noticed that when the interlacings of the warp ends are shown in this manner, the interlacings of the filling must necessarily also be shown, since when a square is filled in it not only shows that the warp end is up at that point but also indicates that the filling at that point is under the warp; and when a square is left blank it not only shows that the warp end is down at that point but also that the filling is over the warp end. Therefore, when the ends have been shown on design paper, the picks also have been shown, and consequently (*b*) shows where the filling is up and where down in the same manner as it shows where the warp is up and where down. That this is so may be seen by referring to (*c*), which is exactly the same as (*b*) except that in this case the lines are drawn from the picks in (*a*) to the rows of squares in (*c*) that represent the respective picks. If the picks are followed from (*a*) to (*c*) in the same manner as the ends were followed from (*a*) to (*b*), it will be seen that (*c*) shows the interlacings of the picks. Therefore, since (*b*) is the same as (*c*), either will show the weave of the cloth equally well.

In Fig. 3, (*d*) is a method of showing the interlacing of one pick of filling with the warp and represents the manner in which either of the picks *b* and *d* interlaces with the warp ends, the curved line showing the pick of filling and the circles, sections of the warp ends. As shown, the pick is over the first and under the second warp end, etc.

7. Another very important point to be noticed in this connection is that every other end is alike and every other pick is alike. By examining Fig. 3 (*a*) it will be seen that the first, third, and fifth ends are alike and also that the ends marked *2*, *4*, and *6* are similar to each other, while the picks marked *a*

and *c* are alike as also *b* and *d*. From this it will be seen that in the case of a plain weave it requires only 2 ends and 2 picks to show the manner in which all the ends and picks interlace. Or, in other words, 2 ends and 2 picks show one *repeat* of the weave, all the other ends and picks being simply repetitions of these 2 ends and 2 picks. Fig. 4 shows one repeat of the plain weave represented on design paper.

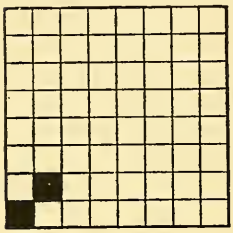
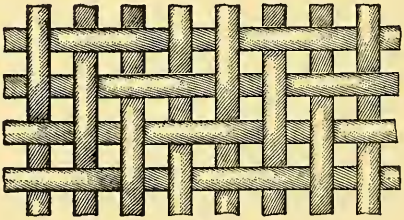


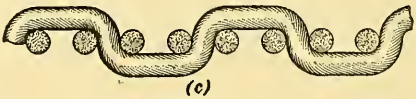
FIG. 4

All weaves repeat on a certain number of ends and picks. It need not necessarily be two ends and two picks, nor is it necessary for the ends to repeat on the same number as the picks, but each must repeat at some time. To illustrate this point further Fig. 5 is given; (*a*) shows a weave on design paper; (*b*) shows the manner in which the ends and picks interlace; and (*c*) shows one of the picks interlacing with the warp ends. If each end in (*b*) is compared with the representation of the corresponding end in (*a*), it will be seen that (*a*) is the weave of (*b*). When speaking of the first end of a weave, the one at the extreme left is always intended, while the first pick is the one at the bottom; the first end and first pick are represented in all cases by the square in the lower left-hand corner. Referring to (*a*), notice carefully the interlacings of each end. It will be seen that the first, second, third, and

(*a*)



(*b*)



(*c*)

FIG. 5

fourth are all different, but that the fifth is like the first, the sixth is like the second, the seventh is like the third, and the eighth is like the fourth. If more ends were shown they would repeat in the same manner; therefore, it will be seen that this weave is complete on 4 ends and that at (*a*) and (*b*) two repeats are shown. If more picks were shown the fifth pick would be like the first, and so on; therefore, the weave is complete on 4 picks. Consequently, one repeat of this weave occupies 4 ends and 4 picks. With every weave, the number of ends and picks that constitutes a repeat should be carefully determined.

HARNESS DRAFT

8. Every end in the warp that interlaces with the filling differently from the others must be drawn through a separate harness in the loom, but every end in the warp that works in a manner similar to some other end may be drawn through the same harness as that other end, provided that it is drawn in its regular order. Thus in the case of the plain weave, if every even-numbered end is drawn through one harness and every odd-numbered end is drawn through another harness and these two harnesses are made to rise and fall alternately, or first one and then the other is lifted, and a pick of filling passed through each opening, cloth similar to that shown in Fig. 1 will be formed.

The method, or order, of drawing each end of a weave through the loom harnesses is usually indicated on design paper by means of a draft, generally called the **harness draft,** but frequently designated as the **drawing-in draft.** This is best indicated with figures, but may be shown by means of crosses, dots, etc. In Fig. 6, (*a*) shows the plain weave extended on 8 ends, while (*b*) shows the harness draft—that is, through which harness each end is drawn. The number over each end in the weave (*a*) indicates the number of the warp end. It will be seen that the first end is drawn through the first harness, as shown in the harness draft (*b*), while the second end, as it interlaces with the filling differently from the first, must be drawn through a separate harness, or

the second, as shown; the third end in the weave works like the first and therefore can be drawn through the same harness as the first end; the fourth end works like the second and is consequently drawn through the same harness as the second. Thus it will be seen that the first end is drawn through the first harness and the next through the second, and that throughout the weave and the warp every alternate end is drawn through the same harness. The harness draft is simply a draft showing the person who draws in the warp ends through which harness each end of the warp is to be drawn, being so constructed that ends having the same interlacings are drawn on the same harness. Harness drafts are generally constructed for only one repeat of the weave, since all other ends are drawn in similarly to the ends in that repeat. Consequently, in making out the harness draft for the plain weave only the first two ends need be shown; therefore, the first two ends in the harness draft, Fig. 6 (*b*), show the manner of drawing in all the ends of the warp.

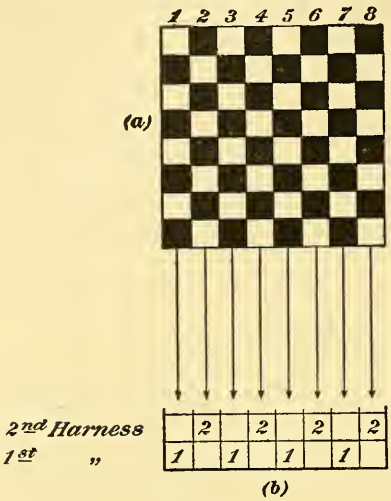


Fig. 6

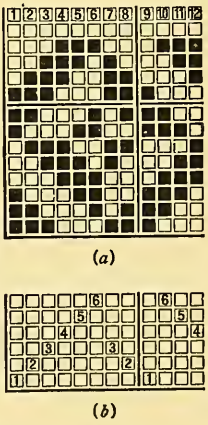


Fig. 7

9. The derivation of the harness draft for the plain weave, although a typical example of the method employed with all weaves, is comparatively simple; hence, to illustrate further this method another example is given in Fig. 7, where (*a*) shows a weave and (*b*) shows the harness

draft. By noticing the weave it will be seen that the first 6 ends interlace with the filling differently; therefore, they must all be drawn through separate harnesses. This is done in the harness draft (*b*), which shows the first end drawn through the first harness, the second end drawn through the second harness, the third end drawn through the third harness, and so on up to the sixth end, which is drawn through the sixth harness. The seventh end of the weave is like the third and can therefore be drawn through the same harness. One point to be noted is that in making out a harness draft each row of squares running across the paper represents a harness. Therefore, when making out a harness draft, as each end is indicated, the number showing through which harness it is to be drawn must be placed in the horizontal row of squares representing that harness. Thus in this case, the number *3*, which shows that the seventh end is drawn through the third harness, is placed in a square that will represent the seventh end and also the third harness, as shown. Continuing with the ends in the weave, it will be seen that the eighth end is exactly like the second; therefore, it can be drawn through the same harness as the second end, or the second harness, as shown. The ninth end is exactly like the first end; therefore, it is drawn through the same harness as the first end, which is the first harness. The tenth end is like the sixth, the eleventh like the fifth, and the twelfth like the fourth; therefore, the tenth end is drawn through the same harness as the sixth end, which is the sixth harness, the eleventh end through the fifth harness, and the twelfth end through the fourth harness, as shown in the harness draft.

CHAIN DRAFT

10. After the harness draft has been made to show the method of drawing in the warp ends, a plan must be made to show how, or in what order, the harnesses must be lifted so that the ends drawn through them will interlace with the filling according to the desired weave, or in other words a plan showing which harnesses are to be raised and which lowered

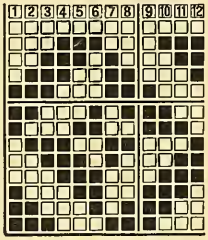
on each pick. This plan is known as the **chain draft** and is obtained from the weave and harness draft as follows: Referring to Fig. 6, it will be seen that the first end has been drawn through the first harness and that all the ends working like the first end have been drawn through that harness; so that if the first harness is raised and lowered in the order indicated by the first end of the weave, all the ends drawn through that harness will be raised and lowered in the same manner and will therefore interlace with the filling in the same way. The second end has been drawn through the second harness and also all the ends that work in a manner similar to the second; consequently, if the second harness is raised and lowered in the same order as that indicated by the second end of the weave, all the ends drawn through that harness will interlace with the filling in a similar manner.

The marks and blanks on the first end of the weave, as shown in (*a*), Fig. 6, indicate the manner in which that end is to be raised or lowered; consequently, by raising the harness through which that end is drawn, or the first harness, in the same manner as the first end is raised, all the ends drawn through that harness will be raised and lowered in their proper order. The marks and blanks on the second end of the weave indicate the manner in which that end must be raised and lowered; consequently, by raising the harness through which that end is drawn, or the second harness, in the same manner as the second end is raised, all the ends drawn through that harness will be raised and lowered in their proper order. This includes all the ends in the warp that work differently, and consequently two harnesses are all that are necessary to produce this weave.

The manner of lifting and lowering the harnesses, or in other words the chain draft, is indicated on design paper by means of blank and filled-in squares, each filled-in square indicating that a harness is raised, while each blank square shows that a harness is lowered. To make a chain draft from the weave and harness draft, commence with the first end and copy the interlacings of each end in one repeat of the weave that is drawn in through a separate harness as indicated by

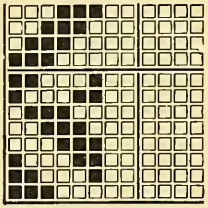
the harness draft, placing these interlacings of the ends in the same relative position that the harnesses through which they are drawn occupy.

Fig. 4 shows one repeat of the weave shown by the diagram Fig. 1, and since the first end is drawn through the first harness, the interlacings of the first end must be copied to show the manner in which this harness should be raised and lowered. The second end is drawn through the second harness; therefore, to show the workings of this harness the interlacings of this end, as shown in Fig. 4, must be copied. When this has been done it will be noticed that the chain draft is similar to the weave as shown in Fig. 4; therefore, this figure can be used to indicate the chain draft as well as to show the weave.



(*a*)

(*b*)



(*c*)

FIG. 8

11. To illustrate further the method of obtaining the chain draft from the weave and harness draft, a chain draft is made for the weave and harness draft shown in Fig. 7. In Fig. 8, (*a*) represents one repeat of the weave; (*b*) shows the harness, or drawing-in, draft; and (*c*) shows the chain draft. The significance of the rows of squares in each figure should be carefully noted. In (*a*), each vertical row of squares represents one end; each row of squares across the design paper, one pick; and each filled square, an end raised over a pick. In (*b*), each vertical row of squares represents one end, the same as in (*a*), but each row of squares across the design paper represents one harness, and each number the harness through which that particular end is drawn. In (*c*), each vertical row of squares represents the working of one harness, or in other words the order of raising and lowering the harness, while each row across the design paper represents one pick, or

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one bar of the chain that is placed on the loom to govern the operation of the harnesses.

To make a chain draft from a weave it is simply necessary to copy the interlacings of those ends that are drawn on separate harnesses. Therefore, in order to ascertain the number of ends that any chain draft will require it is only necessary to find the number of harnesses that the drawing-in draft occupies. By referring to Fig. 8 (*b*), it will be seen that 6 harnesses are used, and thus only six vertical rows of squares, representing the 6 ends of the weave that have different interlacings, will be required for the chain draft. In copying the interlacings of those ends that are drawn on separate harnesses, since the first end is drawn through the first harness, the first harness shown in (*c*) is marked the same as the first end shown in (*a*). The second end is drawn through the second harness, and consequently the second harness shown in (*c*) is marked the same as the second end shown in (*a*). This method is continued with the first 6 ends, all of which are drawn through separate harnesses. The seventh end of the weave is drawn through the third harness, but since the working of this harness has already been set down, it must not be marked again. The same can be said of the rest of the ends, all of which work in a manner similar to some one of the first 6 ends. Therefore, the chain draft is complete as shown in (*c*).

12. The expression **chain draft** is derived from the harness chain used on a woolen or worsted loom, which consists of bars on which rollers, or *risers*, and washers, or *sinkers*, are placed, each bar selecting the harnesses to be raised for 1 pick. With most woolen and worsted looms a roller raises the harness and a sinker causes it to be lowered; thus, wherever a mark is placed in a square of the chain draft, a riser is placed on the harness chain, which will cause that harness to be raised, and wherever a blank square is left in the chain draft, a sinker is placed on the harness chain, which will cause that harness to remain down. The construction of some woolen and worsted looms is such that

the reverse of this statement is true (namely, a roller on the harness chain lowers the harness, while a washer causes it to be raised), so that a mark on the chain draft indicates a washer on the harness chain and a blank square a roller.

The term **pegging plan** is also often used for chain draft, because the pattern chain commonly used on a cotton dobby loom consists of wooden bars into which pegs are inserted. When a square is marked on the chain draft, a peg is inserted in the bar and the harness is raised; when the square is blank, the bar has no peg and the harness remains down.

EXAMPLES FOR PRACTICE

1. Give the drawing-in draft for Fig. 9.

2. Give the chain draft for Fig. 9 to correspond with the drawing-in draft shown in answer to question 1.

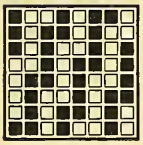


FIG. 9

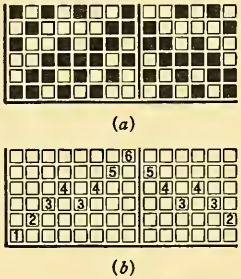


FIG. 10

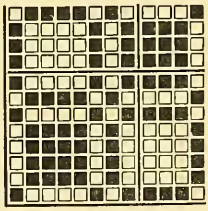


FIG. 11

3. Fig. 10 (*a*) and (*b*) shows a weave and drawing-in draft; give the chain draft to correspond with the drawing-in draft.

4. Give the drawing-in draft for the weave shown in Fig. 11, placing all ends that work alike on the same harness.

5. Give the chain draft for Fig. 11 to correspond with the drawing-in draft shown in answer to question 4.

THE EFFECT OF THE WEAVE

13. The weave, harness draft, and chain draft have thus far been explained in connection with specific cases, but these subjects will now be dealt with in a more general way. The weave may be said to influence the build of the fabric; for instance, if the interlacings of the different ends are not equally balanced, that is, if all the ends in one repeat of the weave do not interlace about the same number of times, it will be impossible to obtain a regular and uniform cloth. Fig. 12 shows a weave that will serve to illustrate this point.

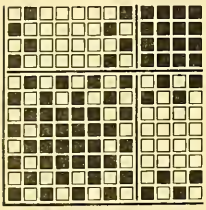


Fig. 12

By examining this weave it will be noticed that the first, second, seventh, and eighth ends make twelve interlacings, while the remaining ends make only four interlacings in one repeat of the weave. A warp end is said to interlace, or to make one interlacing, each time that it passes through the cloth from the face to the back or from the back to the face; that is, an interlacing is made each time that the warp end is raised over, or depressed under, one or more picks. In the same way a pick is said to make an interlacing each time that it passes over or under one or more warp ends. Those ends and picks that make the greater number of interlacings will naturally be woven tighter than those that make fewer interlacings; therefore, with such a weave as is shown in Fig. 12 it is not possible to produce a level cloth. This weave is known as a *honeycomb*, and a level cloth is not desired but rather one with a honeycombed effect.

The number of interlacings in a weave affects the length of warp required to weave a given length of cloth. For example, if cloths having the same number of picks per inch and the same counts of yarn were woven with the weaves shown in Figs. 3 and 5, the cloth made with the weave in Fig. 3 would require a longer warp than that woven with the weave shown in Fig. 5, if the same number of yards of each cloth were desired. This may be demonstrated by taking a

piece of thread and interlacing it two or three times between the fingers of one hand, having the thread pass over one finger, under the next, over the next, and so on, noting the length of thread that is taken up, and afterwards passing the thread back and forth again the same number of times but having it pass over two fingers and under two fingers, when the difference in the lengths required in the two operations may be noticed. It will be found that the length of the thread increases with the interlacings. It is exactly the same principle that necessitates a longer warp when there are more interlacings of the ends and picks. The interlacings also affect the number of ends and picks that can be placed in 1 inch of the cloth; the general rule being that the greater the number of interlacings, the smaller is the number of ends or picks that can be crowded together.

The weave also affects the appearance of the cloth, since it is possible to produce a great many patterns in woven fabrics by simply changing the method of interlacing the warp and filling, no variety of colors or yarns being needed. Again, a weave may be used in a figured design that will influence the development of the details of the pattern; for instance, it may be desired to have a certain effect or to bring certain colors to the face of the cloth in some parts of the design.

STANDARD TYPES OF HARNESS DRAFTS

14. Straight Drafts.—The simplest method of drawing the warp ends through the harnesses is that employed with the plain weave. As previously explained, in this weave there are only 2 ends in one repeat of the weave and they are drawn through 2 harnesses, first an end through one harness and then the next end through the other harness, and so on. This method of drawing in the warp ends is a standard method and is known as the *straight draft*. A **straight draft** is not confined to 2 harnesses, but may be defined as a draft in which the ends are drawn through the harnesses in regular order from front to back. To illustrate this, suppose that a weave occupied 10 harnesses instead of 2 harnesses and that the

ends were drawn straight from the front harness to the back harness. Then the first end would be drawn through the first harness, the second end through the second harness, the third end through the third harness, and so on, ending with the tenth end, which would be drawn through the tenth harness. The draft would then commence another repeat with the first harness again, and the next, or eleventh, end would be drawn through that harness, the twelfth end would be drawn through the second harness, and so on. The harness draft is repeated in this manner until all the ends in the warp have been drawn in. It will be noted here that when the

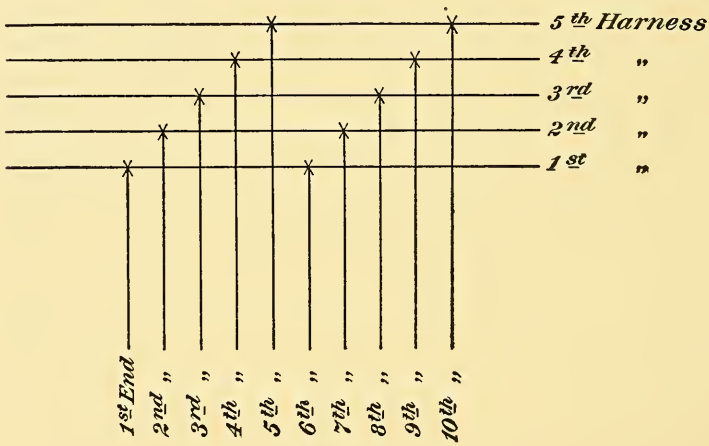


Fig. 13

warp is actually being drawn through the harnesses it is more convenient to read the drawing-in draft in reverse order, that is, from right to left, commencing on the right of the harnesses and drawing from back to front; however, this will not affect the result in the least.

Fig. 13 shows two repeats of a straight drawing-in draft on 5 harnesses and also illustrates another method of representing the harness draft, the lines running across the page representing the harnesses, the vertical lines indicating the warp ends, and the crosses showing through which harness each warp end is drawn. In Fig. 13, the first end is drawn

through the first harness, the second end through the second harness, and so on up to the fifth end, which is drawn through the fifth harness, whereupon the draft commences to repeat, that is, the next end, which is the sixth, is drawn through the first harness, the seventh end is drawn through the second harness, and continues in this manner up to the tenth end, which is drawn through the fifth harness. Here the harness draft commences to repeat again and the next end, which is the eleventh, if it were shown, would be drawn through the first harness.

15. Point Drafts.—Another method of drawing in warps that is used quite extensively is known as the *center*, or *point, draft*. In **regular point drafts,** the ends are drawn from the front to the back harness and then the order of drawing in is reversed; that is, after drawing in the end in the back harness the next end, instead of being drawn on the front harness as in the straight draft, is drawn through the next to the back harness and the ends then drawn in regularly from back to front. Fig. 14 is an illustration of a regular point draft on 8 harnesses in which the first end is drawn through the first harness, the second end through the second harness, and so on up to the eighth end, which is drawn through the eighth harness. The next, or ninth end, instead of being drawn through the first harness, as in a straight draft, is drawn through the next to the back, or the seventh, harness and the ends then drawn in from back to front, or in reverse order, the fourteenth end being drawn in through the second harness. The draft commences to repeat here.

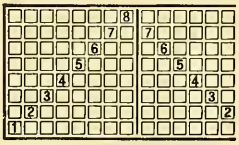


Fig. 14

With a point draft it should be carefully noted that the last end of the repeat should always be drawn through the second harness, that is, if the draft is commenced on the first harness, and that the drawing-in draft should never commence and end with the same harness. It should also be noticed that a regular point draft is always complete on a

number of ends that is two less than twice the number of harnesses employed. Thus, in Fig. 14, the draft occupies 8 harnesses, and one repeat is complete on 14 ends, which is according to the rule, as follows: $2 \times 8 = 16$; $16 - 2 = 14$, the number of ends on which one repeat of the draft is complete.

Another type of point draft, illustrated in Fig. 15, is known as the **irregular point draft.** In these drafts the ends are drawn through the harnesses straight for a certain number of times and then reversed as in a regular point draft; thus in Fig. 15, for example, the ends are drawn in straight on 7 harnesses three times and then reversed. It will be noticed that the last end of the repeat is drawn through the second harness, as previously explained. Still another type of irregular point draft is illustrated in Fig. 16. The method adopted in this case is that of drawing the ends straight for a certain number of harnesses and then reversing, but only running the ends

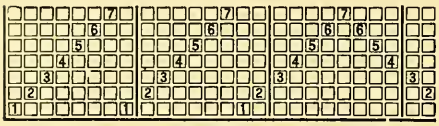


FIG. 15

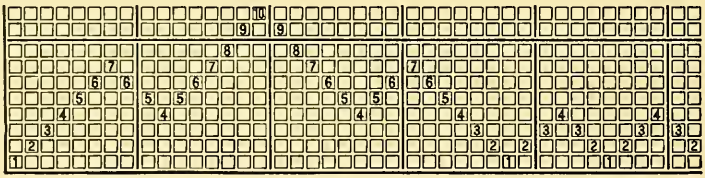


FIG. 16

for a few harnesses, when they are again run straight and again reversed, etc. It will be noticed that a repeat of the draft occupies 10 harnesses and 42 ends, and also that the last end of the repeat is drawn through the second harness.

16. Angled Drafts.—In the method of drawing in the warp ends known as the **angled draft** they are drawn straight for a certain number of harnesses and then reversed, but instead of the reversing starting with the next to the back harness as in the point draft, it is started on an intermediate

harness, generally half way between the first and last harnesses, but depending somewhat on the chain draft that is to be used. Fig. 17 shows an angled draft on 8 harnesses in which the first 8 ends are drawn straight and the method of drawing in then reversed, but instead of commencing with the seventh harness and drawing the ninth end through that harness as in a regular point draft, the ninth end is drawn through the fourth harness, the tenth end through the third harness, and so on until an end has been drawn through each harness, which completes one repeat of the draft.

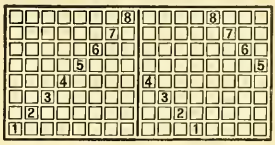


Fig. 17

17. Skip Drafts.—The skip draft may be considered as a straight draft drawn in sections with one or more harnesses skipped between the sections. Fig. 18 shows a skip draft on 4 harnesses in which the first section of 4 ends is drawn in straight; then 1 harness is skipped and the next section of 4 ends drawn straight, then another harness skipped and the next section drawn in straight, and so on. Thus it will be noticed that the fourth end is drawn in on the fourth harness, but the fifth instead of being drawn in on the first harness as in the straight draft, is drawn in on the second harness. In the same way the eighth end is drawn in on the first harness, but the ninth, instead of being drawn in on the second, is drawn in on the third, and so on. It will be noticed that this draft repeats on 16 ends, since if it were continued the seventeenth end would be drawn in on the first harness, as the fourth would be skipped. Thus the seventeenth end would be the first end of the next repeat of the draft. In the draft shown in Fig. 18 only 1 harness is skipped between the sections, but it is perfectly feasible to skip any desired number

Fig. 18

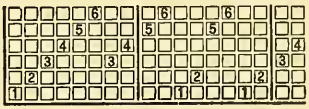


Fig. 19

In Fig. 19 a skip draft on 6 harnesses is shown in which 2 harnesses are skipped between the sections. In this draft the first 6 ends are drawn in straight, but the seventh end skips 2 harnesses and starts on the third, while the thirteenth end, instead of being drawn in straight, skips 2 harnesses and begins on the fifth. In this draft there are really three sections and the draft repeats on 18 ends, since the nineteenth end, if shown, would start on the first harness, the fifth and sixth being skipped.

18. Satin Drafts.—Satin drafts are really adaptations of the skip-draft principle in which harnesses are skipped between the ends instead of between sections of ends. Thus in the 5-harness satin draft shown in Fig. 20, the first end is drawn in on the first harness; the second end is drawn in on the third harness, skipping the second harness; the third end is drawn in on the fifth harness, skipping the fourth harness; the fourth end is drawn in on the second harness, skipping the first harness; and the fifth is drawn in on the fourth harness, skipping the third harness. In this satin draft only 1 harness is skipped between the ends, but in the 8-end satin draft shown in Fig. 21, 2 harnesses are skipped between the ends; thus, the first end is drawn in on the first harness; the second end on the fourth harness, skipping the second and third harnesses; the third end on the seventh harness, skipping the fifth and sixth harnesses; the fourth end on the second harness, skipping the eighth and first harnesses; and so on. It will be noticed that satin drafts repeat in the same manner as the skip drafts; thus in Fig. 20 the sixth end would be drawn in on the first harness, the fifth harness being skipped between the fifth and sixth ends, and in Fig. 21 the ninth end would be drawn in on the first harness, skipping the seventh and eighth harnesses between the eighth and ninth ends.

Fig. 20

Fig. 21

19. Section Drafts.—A section draft may consist of any one or more of the foregoing styles of drafts arranged so

as to be repeated in sections throughout the width of the cloth. Thus Fig. 22 shows a section draft on 12 harnesses, and as indicated by the brackets the method of drawing in the first section of 4 ends is to be repeated three times, and the method of drawing in the second and third sections of 4 ends is to be repeated the same number of times. Thus, it will be seen that this is really a short method of indicating a comparatively large draft, since if this draft were extended fully as indicated, it would occupy 36 ends, as shown in Fig. 23. This section draft is simply an amalgamation of straight drafts in sections, but it is not necessary to use

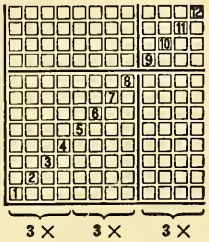


Fig. 22

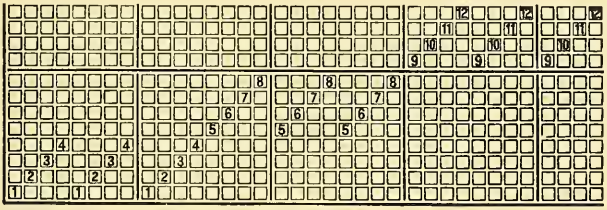


Fig. 23

straight drafts, since angled, skip, or satin drafts may be extended in sections in the same manner.

EFFECTS OF THE HARNESS AND CHAIN DRAFTS

20. That different drawing-in drafts will give widely different results in the cloth, even if the same chain draft is used, is readily apparent. The effect that will be produced in a cloth by any harness and chain draft may be easily ascertained by simply copying the interlacings of each end of the chain draft in the order indicated by the harness draft. The effect is practically the weave, and consequently finding the effect when the harness and chain drafts are given is simply the reverse of finding the harness and chain drafts when the weave is given.

To illustrate this, suppose that Fig. 24 is a chain draft for a weave and that the ends are drawn in straight on 8 harnesses; then the effect in the cloth will be exactly like the chain draft, since the first end will work like the first harness of the chain draft, and consequently the interlacings of that end will correspond to the rising and falling of that harness. Since the second end works like the second harness and so on throughout the draft, the effect will be exactly like the chain draft. When a straight harness draft is used, the chain draft is always exactly like the weave; and on the other hand, the effect, or weave, produced by any chain draft with a straight harness draft is always like the chain draft. Suppose that the same chain draft, Fig. 24, is used, but that the harness draft in Fig. 14 is used in place of the straight draft, and it is desired to find the effect that will be produced in the cloth. As previously stated, the manner in which the harnesses rise and fall, as shown in the chain draft, will give the manner in which the ends drawn through those harnesses interlace with the filling; therefore, if it is desired to learn how a certain end interweaves, it is simply necessary to copy the order of lifting and lowering the harness through which that end is drawn, and since the harness draft shows through which harness any end is drawn, while the chain draft shows when each harness is up and when down, it is possible from these two drafts to tell exactly how each end interweaves. Proceeding in this manner, in order to find the effect produced with Fig. 24 as a chain draft and Fig. 14 as a harness draft, since the first end is drawn through the first harness it will rise and fall with that harness, and consequently the lifting of the first harness as shown in the chain dratt represents the manner in which the first end interweaves and is therefore copied for the first end of the effect, as shown in Fig. 25. The second end is drawn through the second harness and the lifting and lowering of

Fig. 24

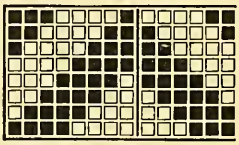


Fig. 25

this harness is therefore copied in order to show the interweaving of this end, and so on up to and including the eighth end; but the ninth end is drawn through the seventh harness, and therefore to show the interweaving of this end it is necessary to copy the order of lifting and lowering that harness as shown in the chain draft. Continuing in this manner until the interlacings of all the ends shown in the harness draft have been copied from the chain draft, the effect shown in Fig. 25 is obtained.

21. For another example suppose that the same chain draft is used with the harness draft shown in Fig. 17 and that it is desired to find the effect that will be produced. Fig. 26 shows the effect, and it is hardly necessary to go into any detailed explanation of the manner in which this is obtained except to call attention to the ninth end. By noticing the harness draft, Fig. 17, it will be seen that the ninth end is drawn through the fourth harness; therefore, in representing this end in the effect it is necessary to copy the lifting and lowering of the fourth harness as shown in the chain draft. By noticing the effect, Fig. 26, it will be seen that the working of the ninth end is similar to the working of the fourth harness as shown in the chain draft, Fig. 24. The working of the tenth end is similar to the working of the third harness, since it is drawn through that harness; the working of the eleventh end is similar to the working of the second harness, since the eleventh end is drawn through that harness; and, in short, by examining the ends as shown in the effect, Fig. 26, it will be seen that they all work in a manner similar to the harnesses through which they are drawn.

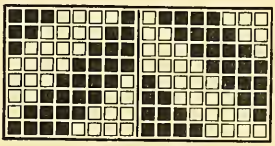


Fig. 26

Fig. 27

Fig. 28

For another example suppose that it is desired to find the weave produced by the skip draft shown in Fig. 18 with the

chain draft shown in Fig. 27. The first section of 4 ends is drawn in straight; therefore, these ends will be the same as the chain draft; then, according to the drawing-in draft, the fifth end is like the second, the sixth is like the third, the seventh is like the fourth, the eighth is like the first, the ninth is like the third, and so on, as shown by the completed weave in Fig. 28.

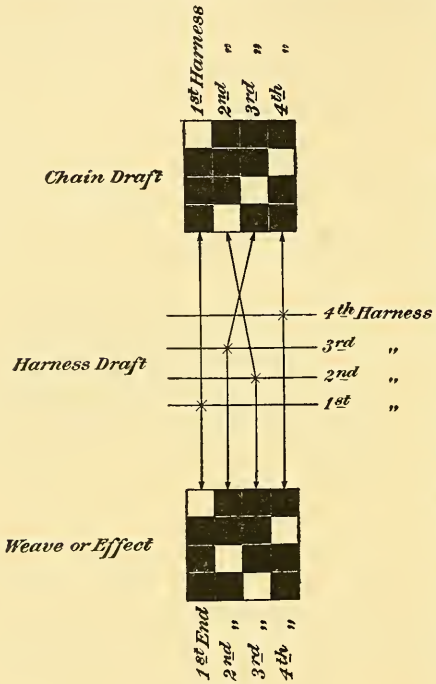


FIG. 29

A final example of the relation between the harness draft, the chain draft, and the effect is shown in Fig. 29. In this figure, the first end, as shown in the harness draft, is drawn through the first harness; therefore, the first end in the weave will be like the first harness in the chain draft. The second end is drawn through the third harness; therefore, the second end in the weave will be like the third harness in the chain draft. The third end is drawn through the second harness; therefore, the third end in the weave will be like the second harness in the chain draft. The fourth end is drawn through the fourth harness; therefore, the fourth end in the weave will be like the fourth harness in the chain draft.

22. From these explanations, it will be seen that by simply altering the harness draft several effects in the cloth can easily be obtained from one chain draft. On the other hand, it will readily be understood that it is possible to

obtain different effects with the same harness draft by simply changing the chain draft, since if the harnesses are made to rise and fall differently it will of necessity cause the ends drawn through these harnesses also to rise and fall differently, thus changing the manner of interweaving the ends and consequently changing the weave. It should, however, be carefully noted that the chain draft and harness draft must always occupy exactly the same number of harnesses.

POINTS TO BE CONSIDERED WHEN CONSTRUCTING HARNESS DRAFTS

23. As has already been shown, when two or more ends in one repeat of a weave have the same interlacings it is possible to draw such ends through the same harness, but it is not always advisable to do so. It would be possible, if the loom would operate the necessary number of harnesses, to draw each end in one repeat of a weave through a separate harness, or in other words to use a straight draft for every weave, in which case one repeat of the weave would always be the chain draft; but owing to the large number of ends occupied by a single repeat of some weaves, it is not always practicable to do so, and consequently it becomes necessary to draw all or some of the ends working alike through the same harness. However, this is a matter in which a person must use his judgment to a large extent, constantly remembering that the nearer the method of drawing in can be brought to a straight draft, the better it will be for the weaving in every way.

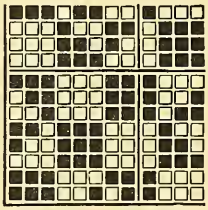
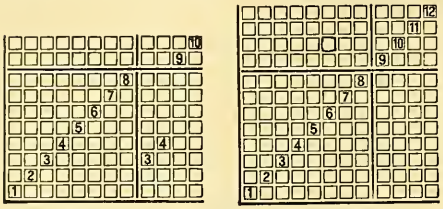


Fig. 30

As an illustration, suppose that the weave shown in Fig. 30 was to be used and that it was desired to make the harness draft. By carefully noting the weave it will be seen that the ninth end works like the third and can therefore be drawn through the same harness as the third end, which is the third harness, and also that the tenth end works like the fourth end

and can therefore be drawn through the harness with the fourth end; thus, the harness draft could be made out as Fig. 31 (*a*), and woven with 10 harnesses, but it will be noticed that by so doing a break is made in the drawing-in draft, which makes it more difficult to draw in the warp and also more difficult for the weaver to draw in any ends that might break out during weaving. A better plan, therefore, is to draw the ends in straight on 12 harnesses, as shown in Fig. 31 (*b*).



(*a*) (*b*)

FIG. 31

24. In order that a better understanding of this subject may be obtained, suppose that it is desired to draft the weave shown in Fig. 32 in the most practical manner. Examining this weave, it will be seen that the first 3 ends are entirely different; therefore, the first end will be drawn through the first harness, the second end through the second harness, and the third end through the third harness. Next it will be seen that the fourth end is like the second and therefore can be drawn through the harness with the second end; also that the fifth, sixth, seventh, and eighth ends interlace in a manner similar to the first, second, third, and fourth, respectively, and therefore can be drawn in the harnesses in the same manner as the first four; and so on up to and including the twenty-fourth end. It will be noticed that the twenty-fifth end works like the ends drawn through the first harness, while the twenty-sixth works like those drawn through the third harness; therefore, these ends are drawn

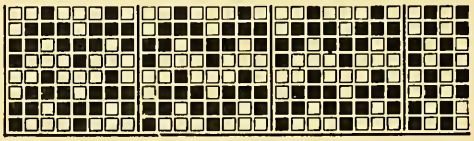


FIG. 32

through the first and third harnesses, respectively. The twenty-seventh end is similar to the twenty-fifth, and the twenty-eighth is like the twenty-sixth. If the ends are drawn in this manner, the harness draft will be like Fig. 33 and the chain draft like Fig. 34.

As previously stated, however, a harness draft should be made out in such a manner that the design can be woven as easily as possible. It will readily be understood that by placing all the ends on 3 harnesses they are more crowded on one or more of the harnesses than if they were placed on more harnesses. Again, increasing the number of ends in the harnesses always adds to the difficulty the weaver has in drawing in the broken ends, and especially so if the warp contains a large number of ends per inch. Another consideration when drafting is to have as nearly as possible the same number of ends on each harness, for then there will be a uniform strain on the harness motion of the loom; while on the other hand, if some harnesses contain more ends than others, heavy and light lifts are forced on the loom mechanism at different times, and a jerky movement of the loom is generally the result.

Fig. 33

Fig. 34

By noticing Fig. 33, it will be seen that in one repeat of the drawing-in draft 8 ends are drawn through the first and third harnesses, while 12 ends are drawn through the second harness. As a result of this method it would necessarily take more power to lift the second harness than the first or third. In order to remedy this, suppose that instead of drawing the ends as shown in Fig. 33, the first end is drawn through the first harness, the second end through the second harness, the third end through the third harness, the fourth end through the fourth harness, and that this order is repeated until the twenty-fifth end is

Fig. 35

Fig. 36

reached, which is drawn through the first harness, while the twenty-sixth end is drawn through the third harness, the twenty-seventh through the first, and the twenty-eighth through the third. The harness draft for the ends when drawn in this manner is shown in Fig. 35, while Fig. 36 shows the chain draft for this harness draft. It will readily be understood that such an order of drawing in the ends is preferable to that shown in Fig. 33, since the draft is easier for the weaver and drawing-in girl, as well as for the loom.

EXAMPLES FOR PRACTICE

1. Fill 8×8 small squares of design paper with the plain weave and show the harness and chain drafts that would be used if the cloth were to be woven on 4 harnesses with a straight drawing-in draft.

2. A plain cloth is to be woven on 4 harnesses with the first end drawn through the first harness, the second end through the third harness, the third end through the second harness, and the fourth end through the fourth harness; show the chain draft.

Fig. 37

3. Show the effect that would be produced in the cloth by using a regular point draft with Fig. 37 for the chain draft.

4. (*a*) Show an irregular point draft on 12 harnesses; (*b*) show the effect that would be produced, using Fig. 7 (*a*) for a chain draft.

ANALYSIS OF COTTON FABRICS

Serial 503 Edition 1

PARTICULARS TO BE DETERMINED BY ANALYSIS

INTRODUCTION

1. An important part of every designer's duties is the analysis of fabrics that are sent to the mill from commission houses, from abroad, or from other sources with a view to their reproduction, either as exact duplicates or with certain modifications that the requirements of the buyer or the mill may demand. This analysis, while seemingly of a secondary nature, is of the utmost importance, not only in cases where a mill desires to manufacture certain fabrics for which there is, or is likely to be, a large demand, but also for the purpose of gaining ideas for the production of other fabrics. By the term **cloth analysis** is meant the process of finding all the requirements necessary to reproduce a certain fabric from a given sample. It may not be desired to exactly duplicate the sample, as certain changes in the weight of the goods, the quality of the material used, etc., are often deemed advisable in order to produce a fabric, seemingly the same, that can be placed on the market at less cost. Thus, a sample of cloth may be given to the designer with instructions either to reproduce the goods exactly, or with certain alterations tending to reduce the cost of the goods without materially affecting the appearance. In the case of a small mill that

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does not regularly employ a designer, this duty is generally performed by the superintendent or boss weaver.

A sample of cloth may be analyzed by several methods, but it is only by the systematic application of some one method derived from a thorough knowledge of the subject that the most economical and advantageous results are obtained. This subject cannot receive too much study, since it is one with which a designer must of necessity be in daily contact. A designer or student of designing should therefore avail himself of every opportunity to analyze such samples of cloth as he may encounter. By this means he will become acquainted with many weaves and characteristic effects and learn to associate them with certain fabrics, thus understanding them much better than it would be possible to understand the bare designs marked out on design paper.

2. In analyzing a sample of cloth, the following list of particulars should be found, the desired finished width of the cloth being given, of course, in all cases:

1. Sley of cloth (average sley if necessary)
2. Ends in the warp
3. Warp pattern (if any)
4. Number of patterns in the warp
5. Picks per inch
6. Filling pattern (if any)
7. Reed to be used
8. Width at reed
9. Yards per pound
10. Counts of warp
11. Counts of filling
12. Weave
13. Harness draft
14. Chain draft

There are also other particulars that should be considered when reproducing a fabric; these, however, will be dealt with later. Several of the items in this list of particulars belong to the subject of cotton-cloth calculations and consequently need no explanation here. In demonstrating the methods of obtaining the other requirements to be found, the same cloth sample will be used that was adopted to exemplify methods of making cotton-cloth calculations.

WARP PATTERN

3. The **warp pattern** is a requirement that is necessary only when the cloth contains warp yarns of different colors, counts, or materials. To illustrate the method of making out a warp pattern it will be assumed that it is arranged as follows: 1 end 30s light blue, 1 end 2/20s white, 10 ends 30s dark blue, 1 end 2/20s white, 10 ends 30s dark blue, 1 end 2/20s white, 1 end 30s light blue, 4 ends 30s white, 1 end fancy, 4 ends 30s white, 1 end fancy, 4 ends 30s white, 1 end fancy, 4 ends 30s white, 1 end fancy, 4 ends 30s white.

The above shows the warp pattern, but this can be shortened somewhat and made to appear to better advantage by arranging the list in the form of a column, enclosing with a brace each portion that is to be repeated and indicating the number of times the part thus enclosed is to be repeated, as follows:

$$\begin{array}{rl} & \text{1 end 30s light blue} \\ & \text{1 end 2/20s white} \\ 2 \times & \left\{ \begin{array}{l} \text{10 ends 30s dark blue} \\ \text{1 end 2/20s white} \end{array} \right. \\ & \text{1 end 30s light blue} \\ 4 \times & \left\{ \begin{array}{l} \text{4 ends 30s white} \\ \text{1 end fancy} \end{array} \right. \\ & \underline{\text{4 ends 30s white}} \\ & \text{49 ends in pattern} \end{array}$$

Another convenient method of showing this pattern and one that is to be recommended is as follows:

WARP PATTERN

30s light blue .	1						1										2
30s dark blue .			10		10												20
30s white . . .								4		4		4		4		4	20
30s fancy . . .									1		1		1		1		4
2-ply 20s white		1		1		1											3
Total number of ends in pattern																	49

Or this could be somewhat shortened, as follows:

WARP PATTERN

30s light blue	1				1				2
30s dark blue			10						20
30s white						4		4	20
30s fancy							1		4
2-ply 20s white		1		1					3
			2 ×			4 ×			

Total number of ends in pattern 49

The marks 2 × and 4 × show that the ends enclosed with a brace are to be taken two times and four times, respectively. By carefully comparing these last two forms, the method adopted in the second one will be readily understood.

In the case of a piece of cloth like the sample that is to be used for analysis, the warp pattern would be known as all white, while the stripe effect produced in the cloth would be obtained by the method of drawing the ends in the reed and the order of raising the harnesses.

FILLING PATTERN

4. By the term **filling pattern** is meant the manner in which the filling is inserted in the cloth either as regards different colors, materials, or different counts of yarn. In making out the pattern of the filling in any cloth, it is simply necessary to give the number of picks of each color or count in one repeat of the pattern; this can be shown in the same manner as was the pattern of the warp. In case the filling is all one color, material, and counts, there will, of course, be no pattern and it will simply be stated as all white, all black, etc., according to whatever color of yarn is used. With the sample of cloth used for analysis, the filling is white and is all of the same counts; consequently, the pattern of the filling would be stated as all white.

PICKING OUT

5. The *weave* is one of the most important particulars concerning a sample of cloth, as without the correct weave it is impossible to reproduce the fabric with a satisfactory resemblance to the original appearance, especially if the fabric has a pronounced weave effect or a color effect depending on the weave for the disposition of the color on the face of the cloth. The method of obtaining the weave from a sample of cloth will require considerable study and practice, although after the weaves of a few samples have been studied and successfully obtained it will be a comparatively easy matter to obtain the weaves of other samples; in fact, many samples will be met with that will not require much more than a glance to determine the weave. The process of obtaining the weave of a woven fabric is known as **dissecting**, or **picking out**, although these terms are sometimes applied to the entire process of cloth analysis. The weave obtained from picking out a sample of cloth is often spoken of as a **pick-out.** By the term **weave** is meant the manner in which the warp yarns and the filling interlace, and is shown on design paper by means of filled-in squares and blanks; that is, by looking at the weave as shown on design paper it is possible to determine just how each thread of the warp is lifted and lowered.

6. When obtaining the weave of a sample of cloth, the first thing necessary is to determine the face and back of the fabric and also which threads form the warp and which the filling. These two points will be dealt with more fully later, but the importance of determining them before commencing to obtain the weave should be mentioned here. If the back of a cloth were taken as the face, the warp ends would be up when in reality they should be down; the reverse would also be true. On the other hand, if the filling were considered as the warp, a correct reproduction of the sample would not be obtained, because the resulting weave would be turned one-quarter way around on the design paper instead of occupying its actual position as in the cloth. In a twilled

cloth this would have the effect of making the twill run in the wrong direction. If the filling were considered as the warp, the weave would also be reversed, since the filling threads would be marked up on the design paper when in reality, since they are filling threads, they should be left blank where they float on the surface of the cloth. After the face and back, also the warp and filling, have been deter-

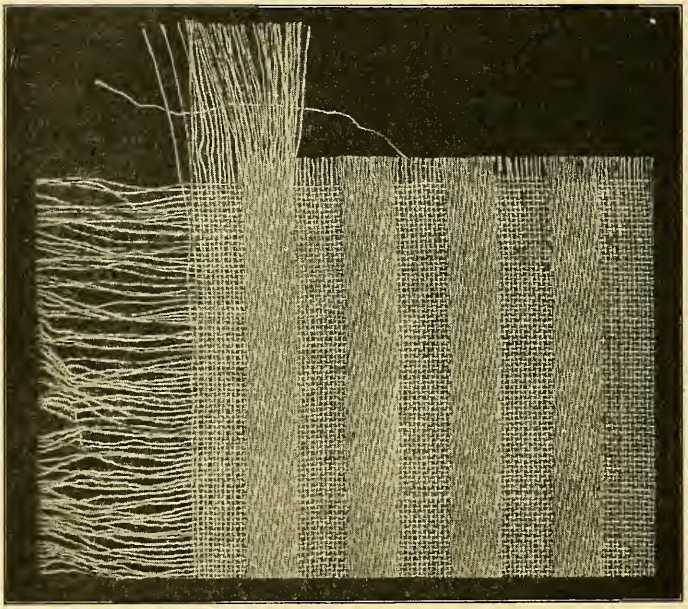


FIG. 1

mined, the sample should be held in such a manner that the face side will be up and the filling will run from side to side.

7. The operation of finding the weave of a sample of cloth consists of picking out one pick of filling at a time and setting down on the design paper the way in which it interlaces with the warp. Thus, if the filling passes over the first end, the square on the design paper representing where that end intersects with the pick under consideration will be left blank, showing that the warp is depressed and that the

filling is on the face of the cloth at that point. If the filling passes under the next end, the square on the design paper representing where the second end intersects with the pick of filling will be filled in, showing that the warp end is raised over the filling at that point.

8. Preparation of Sample.—Before commencing to pick out a weave, the sample of cloth needs certain preparation in order to facilitate the operation. Several ends from the left of the sample and several picks from the top should

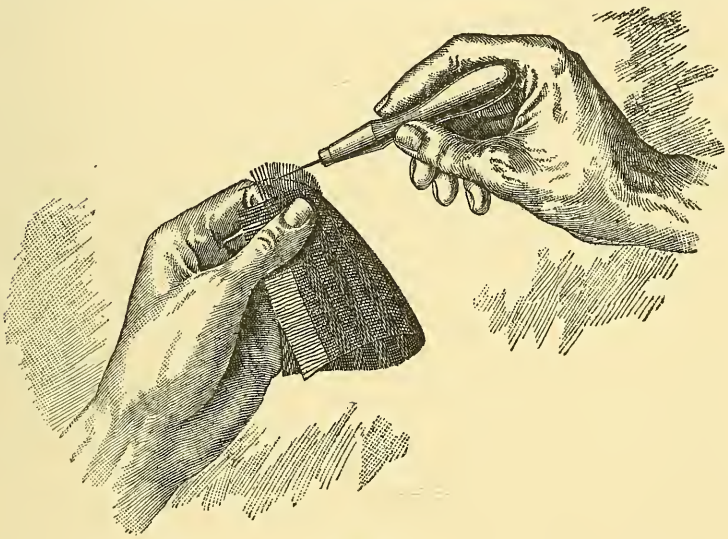


Fig. 2

be pulled out. After the picks have been pulled out, all the loose ends should be cut off, with the exception of those needed to determine the weave. It is not desirable to leave too many ends at the top, only sufficient to form one repeat of the weave being needed. As this number cannot always be determined accurately until the picking out is completed, a number slightly in excess of those probably required should remain. When prepared, the sample will appear as in Fig. 1, which is a slightly enlarged photographic reproduction of the sample under consideration when ready to be picked out.

9. After preparation, the sample should be held in the left hand and laid over the first finger, as shown in Fig. 2, so that when an end has been dealt with, it can be drawn under the thumb and held out of the way while determining the intersection of the next end; in this manner it is possible to keep the ends separate and determine their interlacings more readily. For manipulating the ends and picks when determining the interlacings of the weave and when removing the picks from the cloth, an instrument known as a *picking-out*, or *dissecting*, *needle* is used. This consists simply of a stout needle, usually inserted in a wooden handle so that it may be conveniently grasped.

A method that may be used to advantage in many cases is to lay the sample on a white surface if it contains dark-colored yarns, and on a black surface if the yarns are light-colored. By this means the interlacings will often show up much more prominently, especially when working by artificial light. When this second method is used, a *pick glass* will often be of great aid in determining the interlacings of the warp and filling, especially if the sample is woven of fine yarns or if it contains a large number of ends and picks per inch. A **pick glass**, or **linen tester**, as it is sometimes called, is a simple lens, or magnifying glass, contained in a suitable support; it is also used to enable the number of ends or picks per inch to be readily counted. A pick glass with a field of less than 1 inch is undesirable for purposes of analysis.

In either method, the next step is to draw the top pick up a little from the cloth until its interlacings with the ends that have been left can be readily seen. Beginning with the end on the left and taking each end in successive order, indicate on the design paper whether the pick of filling is above or below each end; that is, if the pick is above an end, the square on the design paper is left blank; if the pick of filling is below an end, the square is marked. Proceed in like manner with each end until a repeat is found. It is well to carry the first few picks out two repeats in order to make sure that a repeat of the weave has been found, after which the extra ends may be cut off, as shown in Fig. 1.

The interlacings of the first, or top, pick should be placed on the top row of squares on that portion of the design paper that is intended to be used and the interlacing of the first end, or the end at the left, with the first pick should be shown on the first row of squares at the left on the design paper; that is, the interlacing of the first, or left, end with the first, or top, pick will be shown by the square in the upper left-hand corner of the design paper. The top pick, however, will not be the first pick to be placed in the loom, since this would produce the cloth with the top for the bottom and vice versa. The last pick of the pick-out will therefore be the first pick to be placed in the loom, and consequently the lower left-hand corner of the weave when shown on design paper is considered to represent the interlacings of the first end and first pick. This is difficult for a beginner to understand, but it is simply necessary in this connection to know that when a piece of cloth is picked out after the manner described, the lower left-hand square of the design paper represents the first end and the first pick; this is important when building a harness chain from the draft.

After its interlacings have been found and placed on the design paper, the first, or top, pick should be drawn out of the cloth entirely, and the next pick then drawn up among the loose ends, as when dealing with the first pick. The interlacings of this pick are found and marked on the design paper on the next horizontal row of squares below the row marked for the first pick. After marking the interlacings of the second pick, the third and each successive pick is dealt with in a similar manner until one is found that interlaces in a manner similar to the first pick taken out. This generally indicates that the weave repeats at this point, but it is always a good plan to pick out 3 or 4 picks of filling after it is thought that the weave has commenced to repeat, and compare these with the first picks taken out, to make sure that the weave does repeat at this point. These extra picks must of course be ignored afterwards and only one repeat of the weave used when obtaining further particulars. When one repeat of the weave is obtained, it represents what is repeated as many

times as required in the length and width of the same piece of cloth, and therefore, is all that is necessary.

Some designers prefer to commence at the bottom of a piece of cloth to pick out. In this case, after the interlacings of the first pick have been marked on design paper it is removed from the cloth and the next pick above it examined and marked on the design paper, but in this case it is set down immediately above the one that was first marked. The interlacings of the third pick taken from the cloth are placed above the second, and so on, so that whether the pick-out is commenced at the top or the bottom of the sample, the final result as shown on design paper will be the same.

Some designers also pick out the warp ends instead of picks of filling, marking squares for picks depressed and leaving squares blank for picks raised.

10. The quickest plan of indicating the weave on the design paper when picking out is to prick, with the picking-out needle, the squares that represent warp ends lifted, and then, after the weave has been found, fill in these squares with ink or pencil. This makes it unnecessary to lay down the picking-out needle and take up the pen or pencil every time a square needs to be marked.

If the sample of cloth to be dissected contains a large number of ends and picks per inch, or warp and filling yarns of the same shade, the yarns are liable to become crossed and the wrong end marked on the design paper. To prevent this, it is an advantage first to place the warp threads in a comb, attaching the ends together with mucilage between two pieces of paper in order to prevent their slipping back. If the ends are crossed or in a wrong order when placed in the comb, this fact will be noticed before the weave repeats, and by making a note of where these crossed ends should be, they may be recopied in their proper order after the repeat of the weave is found. This method will be found useful with any cloth difficult to dissect.

A good aid in dissecting warp-backed and double cloths is to cut the backing ends, after the necessary number of picks

have been taken out, about $\frac{1}{8}$ or $\frac{1}{4}$ inch shorter than the face ends. If the fabric is hard felted or has a nap, singe it and scrape off the fiber, being careful not to injure the body of the yarns. In many cases, where the weave of a cloth is regular and one commonly used, such as a regular twill, it will not be necessary after a little experience to pick out more than 1 or 2 picks, since these will show the manner of the interlacings in the whole weave, which can readily be completed without dissecting.

11. Fig. 3 shows one repeat of the weave of the cloth sample. Several different results might be obtained in picking out this one sample of cloth, and yet each be correct. This would be due to the fact that the different pick-outs were not started on the same end or the same pick, in which case the first end of one pick-out would not be the first end

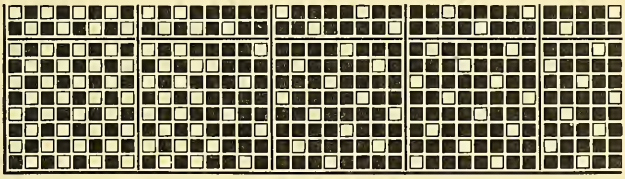


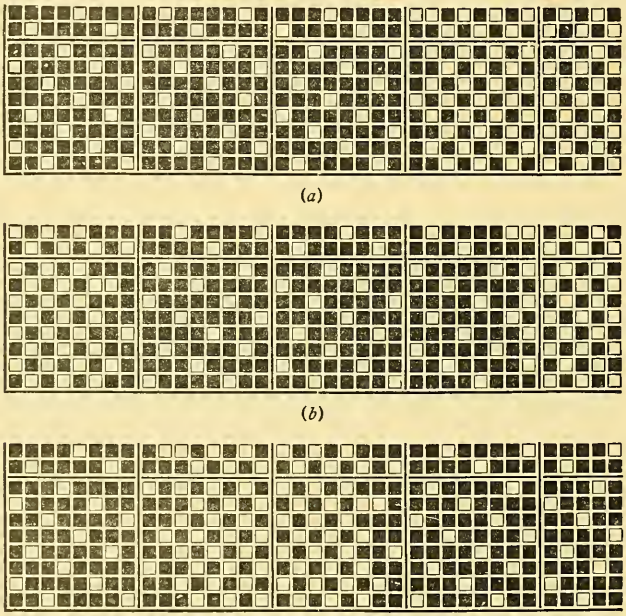
FIG. 3

of the other, or the first pick of one would not be the first pick of the other; or perhaps the pick-out might have been started on both a different end and a different pick.

For instance, if the cloth sample under consideration had been so prepared that the thirteenth end of Fig. 3 was the first end at the left of the sample, with the top pick as there shown still the top pick, the weave in Fig. 4 (*a*) would have resulted. If the sample had been so prepared that the seventh end of Fig. 3 was the first end at the left, the weave obtained would be that shown in Fig. 4 (*b*). Again, if the sample had been so prepared that the twenty-eighth end of Fig. 3 was the first end at the left, the pick-out shown in Fig. 4 (*c*) would have resulted. Though each weave appears to be different from the others, and from Fig. 3, in reality they are all exactly alike, since if repeated several

times in the cloth the same effect will be produced, yet the difference in their appearance is due only to the end on which the pick-out is started.

In a similar manner, if the pick-out had been started on a different pick, it would have had a different appearance, or if it had been started on a different end and different pick from those shown in Fig. 3, the resulting weave would have



(*a*)

(*b*)

(*c*)

FIG. 4

appeared still different. It is usually customary to arrange a combination weave of this character after the manner shown in Fig. 3 or in Fig. 4 (*a*). Designs are sometimes, however, arranged as shown in Fig. 4 (*b*) and (*c*).

By referring to Fig. 3, it will be seen that the first 12 ends of the cloth sample consist of the plain weave, which is complete on 2 ends and 2 picks. Consequently, when picking out a weave of this kind it is only necessary to take out

2 picks in order to learn the weave, after which it may be continued for as many ends and picks as may be desired by simply repeating the first 2 ends and picks. With weaves as simple as this it will be possible, after a little practice, to place the weave on the design paper by simply observing the cloth by means of the pick glass. After the first 12 ends, as shown in Fig. 3, a different weave is employed, and one repeat of this weave is complete on 5 ends, although the entire weave occupies 25 ends. This weave is known as a 5-end warp satin.

One of these weaves, namely the plain weave, is complete on 2 ends and 2 picks, while the satin weave is complete on 5 ends and 5 picks. It might naturally be supposed that in order to show the complete weave only 5 picks would have to be taken out, but the two weaves must repeat together, and a plain weave cannot repeat on an odd number of picks. Consequently, while the satin weave would repeat on 5 picks, the plain weave would not. When two separate weaves are combined in a cloth similar to this one, the weave for the sample will not repeat in its picks until it is continued for a number of picks that is a multiple of the numbers representing the picks on which each weave is complete. Naturally, the least common multiple will give the number of picks on which the entire weave repeats. For example, the plain weave is complete on 2 picks and the satin weave on 5 picks. The least common multiple of 2 and 5 is 10. Therefore, the entire weave is complete on 10 picks.

Another important point that can be illustrated from this sample is the matching up of two weaves when used in the same cloth. By again referring to Fig. 3 it will be noticed that the plain weave is finished on the twelfth end and the satin weave commences on the thirteenth end. In order to have the cloth show as neat an effect as possible, these two ends should *cut*, or oppose, each other; that is, where a square is marked on the twelfth end, the next square to it on the thirteenth end should be left blank. By referring to Fig. 3 it will be seen that on the first pick the twelfth end is down, while the thirteenth end is up; thus they oppose each other.

On the second pick the twelfth end is up and the thirteenth end down, thus causing the 2 ends to oppose each other. They also cut on the third pick, but on the fourth pick both ends are up and consequently do not cut. The effect at this point will not be as neat in the cloth as it is where the ends oppose. However, it is not possible to have a plain weave cut at every point when combined with a 5-end satin.

When desiring to have two weaves cut, both places where the weaves join should be carefully noticed; thus, in Fig. 3 it will be seen that the two weaves not only join at the twelfth and thirteenth ends but also at the first and last, since in showing a second repeat of the entire weave, the first end would be brought next to the last end.

All cloths are not made up of two or more weaves, as this is the exception rather than the rule, and generally a cloth will be found to be made from but one weave repeated a number of times.

HARNESS, OR DRAWING-IN, DRAFTS

12. It is comparatively easy to make the **harness draft** from the weave, but regard should always be had to the best manner of weaving the cloth. Thus, by referring to Fig. 3, which is the weave of the cloth sample shown in Fig. 1, it will be seen that there are more than twice as many ends of the satin stripe as there are of the plain, and by examining Fig. 1 it will be noticed that these ends are cramped or crowded together. In such cases as this it is generally better to place these ends on the front harnesses. As the ends of the satin weave will take at least 5 harnesses, since there are 5 ends working differently, the ends forming the satin stripe, or the last 25 ends in Fig. 3, will therefore be placed on the 5 front harnesses. The reason for placing these ends on the front harnesses is that, as there are more of them, more of them are liable to break during weaving, and it is much easier for a weaver to draw a broken end through a front harness than through a back one. There is also not so much strain on the ends drawn through the front harnesses as there is on those drawn through the back;

consequently, this lessens to a certain degree the liability of these ends breaking.

The ends forming the plain weave will be drawn through the harnesses next to the five on which the ends forming the satin are drawn. The first 12 ends of Fig. 3 could be drawn through 2 harnesses, since they weave plain and every other end works alike, but it will no doubt be found better to draw the ends through 4 harnesses instead of 2 harnesses, since by this means there will be fewer ends drawn through a harness, which will be found to be an advantage in many ways. This draft then will call for 9 harnesses—five for the satin ends and four for the plain. If the loom in which this cloth is to be woven cannot take this number of harnesses but can take seven, the weave must be drafted to 7 harnesses, which is the smallest number on which it is possible for it to be woven.

In many cases there will be found circumstances that will influence the number of harnesses on which to draft a weave. Some of these have been pointed out but many others will be met with in practice; consequently, a student of designing should be constantly looking for new information, especially in a weave room where there is an opportunity for examining a sample of cloth and finding the lowest number of harnesses on which it can be woven and also the actual number of harnesses on which it is being made. If more harnesses are being used than the lowest possible number, the reason should be learned; or on the other hand, if the weave is drafted to the lowest number of harnesses, the reason that extra harnesses are not necessary should be ascertained. It should be stated here that with many weaves it will not be possible to learn the exact number of harnesses that it will take by simply glancing at the pick-out, but it will be necessary to study the interlacings of each end separately and learn if it is similar to any other end in the weave.

13. Beginning with the first end of the pick-out as shown in Fig. 3, this end will be drawn through the sixth harness, the second end through the seventh harness, the third end through the eighth harness, the fourth end through the

ninth harness, and then the ends will commence to repeat; that is, the next end will be drawn through the sixth harness; and so on for the first 12 ends. Commencing next with the thirteenth end, or the first end of the satin weave, this end will be drawn through the first harness, the fourteenth end through the second harness, the fifteenth end through the third harness, the sixteenth end through the fourth harness, and the seventeenth end through the fifth harness. At this point the ends will begin to repeat; that is, the eighteenth end will be drawn through the first harness, and so on. Fig. 5 shows the harness draft complete. In *Cotton Cloth Calculations* it was shown that this cloth contains eighty-eight patterns and 8 ends over, and since the draft shown in Fig. 5 shows how the ends in only one repeat are drawn in, it must be repeated eighty-eight times in order to draw in all the

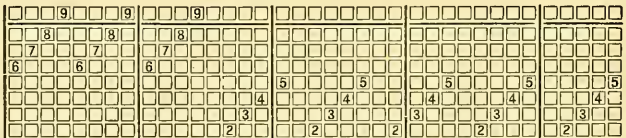


FIG. 5

ends in the warp. The 8 extra ends are to be used for the plain; therefore, the person drawing in the warp will finish by drawing in 8 ends of plain after finishing drawing in the eighty-eight repeats.

By referring to Fig. 5, it will be seen that if, after one repeat has been drawn in, the first end of the second repeat is drawn through the sixth harness, this will bring the same number of ends on each of the last four harnesses. But for the purpose of illustration suppose that there are only 10 ends of plain; then the last end of plain, as shown in the drawing-in draft, will be drawn through the seventh harness, and if the first end of the second repeat is drawn through the sixth harness, this will bring more ends on the sixth and seventh harnesses than on the eighth and ninth. Consequently, the person drawing in the warp can begin the first end of plain in the second repeat on the eighth harness instead of the sixth.

This will give the same effect in the cloth, since the sixth and eighth and the seventh and ninth harnesses work alike; it will also give the same number of ends on each harness.

14. It is always advisable when making out a harness draft first to make it out in such a manner that it will be as nearly a straight draw as possible; this is a great aid to the weaver when drawing in broken ends. Second, as nearly as possible the same number of ends should be placed on each harness; this is a great aid to the good running of the loom. Third, if it is necessary to have more ends on certain harnesses than on others, those harnesses with the most ends should be placed at the front of the loom, unless there is a good reason for not doing so.

CHAIN DRAFT

15. Since the **chain draft** is obtained from the pick-out and the harness draft, it is necessary to have these two items before this draft can be obtained. By referring to Fig. 5 which shows the harness draft, it will be seen that the first end is drawn through the sixth harness; therefore, the interlacings of the first end, as shown in the pick-out, must be the workings of the sixth harness; or in other words, the interlacings of the first end, as shown in the pick-out, give the manner of raising and lowering the sixth harness. The second end is drawn through the seventh harness; therefore, the interlacings of the second end, as shown in the pick-out, give the manner of raising and lowering the seventh harness. The third end is drawn through the eighth harness, and consequently the eighth harness will be raised and lowered as indicated by the third end of the pick-out. The fourth end is drawn through the ninth harness, and the operation of this harness, as shown in the chain draft, will be the same as the fourth end shown in the pick-out. The fifth end is drawn through the sixth harness, but since the working of this harness has already been obtained nothing more needs to be done with this. The same is true of all the ends until the thirteenth

is reached, which is drawn through the first harness; consequently, the interlacing of the thirteenth end, as shown in the pick-out, will give the workings of the first harness. For the same reason, the second harness will work like the fourteenth end of the pick-out; the third harness will work like the fifteenth end of the pick-out; the fourth harness, like the sixteenth end; and the fifth harness, like the seventeenth end. This will complete the chain draft, since the manner of raising and lowering all the harnesses has been learned. Fig. 6 shows the completed chain draft made from the harness draft, Fig. 5, and the pick-out, Fig. 3.

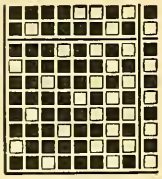


Fig. 6

ADDITIONAL POINTS TO BE DETERMINED BY ANALYSIS

16. In addition to the requirements listed in Art. **2**, there are several items that must in most cases be determined when analyzing a fabric. Some of these items are unnecessary in themselves, but must be ascertained in order that still others may be accurately found. These items are as follows: (1) determination of face and back of fabric; (2) determination of warp and filling; (3) determination of the direction of twist in warp and filling; (4) finding the percentage of contraction in the length of the warp during weaving; (5) the number of beams necessary for the warp yarn; (6) the raw material.

DETERMINATION OF FACE OF FABRIC

17. As previously explained, when desiring to find the pick-out of a sample of cloth it is always necessary first to determine which is the face and which is the back, in order that the results obtained may be accurate for reproducing the cloth.

In most fabrics this is easily done, although some cloths baffle the most experienced designer. The face of a cotton

fabric will sometimes show a much clearer and better pattern than the back. By noticing the cloth sample that has been dealt with, it will be seen that the satin stripe on one side of the cloth shows up much more prominently than it does on the other side. The side that shows the design more prominently is the face. When the fabric is a backed or double cloth, the face can be readily distinguished from the back by means of the style of the cloth or the finish. When dealing with warp-backed fabrics, the face can be readily distinguished from the back, since in this case there will be ends floating for some distance at the back. In a filling-backed fabric, the backing filling floats on the back of the cloth and is generally a soft-twisted yarn in order to give bulk to the cloth.

DETERMINATION OF WARP

18. There are several methods by which the warp may be distinguished from the filling. If the sample submitted for analysis contains a part of the selvage, the warp can be readily distinguished from the filling, since the selvage ends always run in the direction of the warp. In many cases the body of the cloth will be found to be woven from single yarn, while the selvage is woven from 2-ply, or double, yarn. If the yarns in one system are harder twisted, or have more turns of twist per inch, than those in the other, the harder-twisted yarns are generally the warp yarns. If the sample of cloth has what is called a face finish, or nap, the direction of the nap indicates the warp, since these cloths have passed through the machine in the direction of the warp. The counts, or numbers, of the yarn used in each system will often assist in indicating which is the warp and which is the filling, since in many cases the warp yarns are of coarser counts than the filling. If in any case one series of yarn is of different materials, such as cotton and wool or cotton and silk, while the other series of yarn is of one system, the series of yarn that is composed of different systems is generally the warp yarn, although this is not an invariable rule. If one system of yarns has been sized and the other has

not, the former is the warp. This is difficult to determine after the cloth has been finished, but is a good test for brown —i. e., unbleached—cotton goods. If the sample contains reed marks, they will indicate the warp, since they always run warp-way. These marks are caused by the reed wires getting out of place, thereby crowding some of the ends near them and allowing others too much space. In any fabric of a striped character, or in a checked effect in which one direction of the lines is prominent compared with the other, the direction of the stripes or the prominent lines in the check usually indicate the direction of the warp. The twill, if the design is a twill, generally runs up diagonally from the left to the right, so that if the face of the cloth is ascertained it will be readily seen which is warp and which is filling. If one series of yarns is ply and the other single, the ply yarns are generally the warp. In samples of cloth similar to that considered in this Section, the stripes always run warp-way.

DETERMINATION OF TWIST

19. By the term **twist** of yarn is meant both the direction of the twist and also the amount of twist; that is, the number of turns of twist per inch placed in the yarn. The direction of the twist of the yarns in a cloth becomes an important matter when reproducing cloth, since a different effect will sometimes be produced by simply changing the twist in either the warp or filling. Yarns may be twisted in one of two directions, which are technically known as *right twist* and *left twist*. There is considerable difference of opinion as to what constitutes a right-twist or a left-twist yarn, as some mills consider as right-twist what other mills consider left-twist yarn. However, the character of the yarns to which these names are most commonly applied will be explained here.

By holding the yarn between the thumb and forefinger of each hand, the direction of the twist may be learned. If when turning the yarn from the body with the right hand it is twisted harder, it is left-twist; but if the yarn is untwisted

when turned in this manner, it is right-twist. Another method of determining the twist of the yarn is to observe which way the twist marks on the surface of the thread are inclined when the thread is held upright. If they slant up to the left, the yarn is left-twist; if up to the right, it is right-twist. This is the method adopted with screws for determining the twist of the screw thread. Fig. 7 represents a yarn that would be known as a right-twist yarn, while Fig. 8 illustrates a left-twist yarn. By closely examining the warp yarns in the sample, it will be seen that they are right-twist.

Fig. 7 Fig. 8

As previously stated, twist also refers to the number of turns of twist that are put in the yarn in 1 inch. In case of a ply yarn this can be readily ascertained by putting the yarn under the pick glass; or it can be found with more accuracy by untwisting a given length of yarn and dividing the number of turns of twist by the number of inches measured.

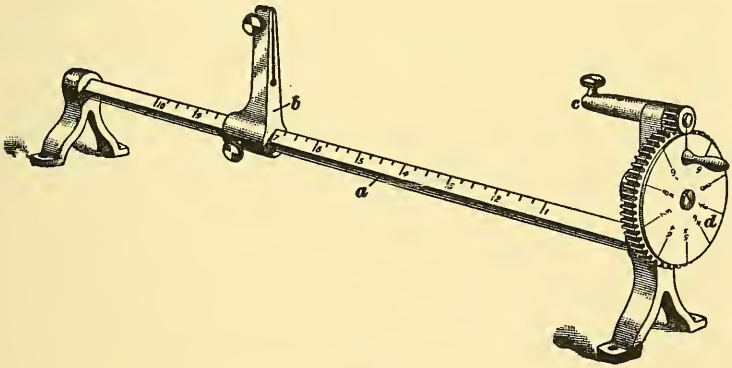


Fig. 9

20. Twist Counter.—The amount of twist in any yarn may be determined by means of an instrument made for the purpose of untwisting the yarn and registering the number of revolutions made in taking out all the twist; this instrument is known as a **twist counter.** The simplest and most commonly used form is shown in Fig. 9. It consists

primarily of two jaws, one of which *b* is capable of adjustment on a bar *a*; the other jaw *c* may be rotated, the exact number of turns that it makes being indicated on a graduated dial *d*. The counter is adapted for finding the number of turns in a sample of yarn from 1 to 10 inches in length, whether right or left twist. The yarn is held firmly by the jaws at a given distance apart as indicated by the position of *b* on *a*; the jaw *c* is then rotated until all the twist is taken out of the yarn, the instrument recording the number of turns on the dial *d*.

TAKE-UP IN WEAVING

21. In making out an order for the amount of warp yarn to be run through the slasher for any loom beam, it will be necessary to learn the probable percentage of contraction that will take place during weaving. For instance, if it is desired to produce 500 yards of cloth from a warp on one loom beam, a somewhat larger number of yards of warp yarn will have to be placed on the beam, owing to the contraction that will take place during weaving. The manner of ascertaining the contraction of any cloth during weaving was dealt with in *Cotton Cloth Calculations*, but it should be borne in mind that no hard-and-fast rules can be laid down for contraction of warp yarns, as this is largely a matter of experience, since some weaves take up much more than others during weaving. The kind of weave, the counts of the warp and filling, and the number of picks per inch are the most important factors that regulate the take-up of the warp, and these should always be carefully considered when desiring to learn the number of yards of warp necessary to weave a certain number of yards of cloth.

NUMBER OF BEAMS REQUIRED

22. In many cases, when desiring to reproduce a sample of cloth, it will be necessary to place the warp yarns on different beams. In some cases as many as four beams are used. For instance, in case a weave that interlaces only once in 6 or 8 picks is combined with plain cloth, the part of

the warp yarn that forms the plain weave will be taken up more rapidly than the other. In such a case it will be necessary to place those ends that form the plain weave on an entirely separate beam, since if this were not done the ends of the plain weave contracting so much more than the other ends would cause the latter to work slack and thus cause a defective cloth. In some cases a cloth may be regular, therefore apparently requiring only one beam, with the exception that at certain intervals there will be a fancy thread that will have different interlacings from the body of the cloth in order that it may produce some desired effect. In this case the fancy threads are placed on a separate beam or, if there are only a few, they are wound on a spool, which may be adjusted at the back of the loom.

When dissecting any cloth, to determine the number of beams required, the weave should be carefully considered. If the cloth is made entirely from one weave, it will be simply necessary to use one beam, but in cases where the cloth is woven with separate weaves, it will be necessary to study these weaves carefully and to ascertain whether one will take up more than the other. The most essential point to notice is the number of interlacings that each weave makes in a certain space. For instance, the ends of one weave may interlace with the filling six times in a certain number of picks, while the ends of another weave may interlace twelve times in the same number of picks. When such is the case, the ends interlacing the greater number of times will, of course, take up much more than the others, on account of their having to bend around the filling much more frequently; consequently, it will be found best in such instances to place the two systems of yarns on separate beams.

Double cloths and cloths backed with warp often require two beams, one for the face warp and one for the back warp, since the back weave is generally different and also because coarser yarns are used for the back of the fabric. If the same yarn and weave are used for the back as for the face of a double cloth, both warps can be put on one beam.

DETERMINATION OF RAW MATERIAL

23. In many fabrics there is a mixture of materials; for instance, cotton and woolen or worsted yarns are often used in the same fabric, as well as cotton and silk. In such cases it will be necessary to determine which yarns are of one material and which are of another. The readiest method of ascertaining the difference between animal and vegetable fibers is to burn some of the yarn. Vegetable fibers are composed of carbon, hydrogen, and oxygen, and when burned will make a flame, emit no odor, and leave an ash. Animal fibers are composed of the same elements together with nitrogen, and when burned will not flame, but smoulder, coil up, and form into a small, crisp globule. They are also distinguished by a peculiar odor that is similar to that of burned horn or feathers. A knowledge of the different fibers is also a great aid in determining the different materials in case threads of different fibers are used in the same fabric. Silk can generally be distinguished from either cotton, wool, or worsted by its incomparable luster and also by the fact that it is generally finer. However, mercerized cotton, which also has a remarkable luster, should not be confounded with silk. These two yarns may be distinguished by burning, as silk is an animal fiber while cotton is a vegetable fiber.

Linen may be distinguished from cotton from the fact that the thread is rougher and contains uneven bunches. It may also be distinguished from cotton by its harsher feeling.

In case it is desired to learn the percentage of the different materials in fancy threads, such as cotton and wool or cotton and silk mixed, or to determine the proportions of each material in a yarn made from two or more different kinds of raw stock, it will be necessary to make chemical tests. When a sample of yarn or cloth is to be tested in this manner it should first be thoroughly washed so as to remove any sizing or foreign matter that may exist. Afterwards dry it thoroughly and weigh it if the percentage of each kind of material is desired.

24. The following tests will cover the separation of silk, cotton, wool, or linen that may be combined in one yarn or cloth. To separate wool from cotton, leaving the cotton: Clean, weigh, and then boil the sample gently for 2 hours in an 8° B. solution of caustic potash; then wash and dry. During the boiling a few drops of water are added from time to time to prevent the alkali from becoming too concentrated. After drying at 100° C. (212° F.), the residue is weighed, which gives the weight of cotton, the loss being the weight of the wool. Instead of potash, a 7° B. solution of caustic soda may be used, and the sample boiled for 15 minutes.

NOTE.—B. means Baumé and refers to the graduated scale on Baumé's hydrometer used for determining the density of a solution.

25. To separate cotton from wool, leaving the wool: Immerse the sample in ammoniacal copper oxide for 20 minutes, after which add water to the solution; then filter and wash, dry and weigh the residue. The weight will be the amount of wool in the mixture.

26. To separate silk, cotton, and wool: Take two samples each of the same weight; boil them from $\frac{1}{4}$ to $\frac{1}{2}$ hour in a 3° B. solution of hydrochloric acid to remove the sizing, etc.; then wash them. Immerse one sample in a boiling solution of basic zinc chloride for a short time; then wash thoroughly, first in acidified and then in clean water, and dry it. The loss in weight gives the amount of silk. Boil the second sample for 15 minutes in a 7° B. solution of caustic soda, and then wash and dry it. The residue is cotton, to the air-dry weight of which must be added about 5 per cent. to compensate for the loss of the fiber during the operation. The difference between this and the original weight represents the weight of wool.

ANALYSIS OF WOOLEN AND WORSTED FABRICS

Serial 504 — Edition 1

PARTICULARS TO BE DETERMINED BY ANALYSIS

INTRODUCTION

1. An important part of every designer's duties is the analysis of fabrics that are sent to the mill from commission houses, from abroad, or from other sources with a view to their reproduction, either as exact duplicates or with certain modifications that the requirements of the buyer or the mill may demand. This analysis, while seemingly of a secondary nature, is of the utmost importance, not only in cases where a mill desires to manufacture certain fabrics for which there is, or is likely to be, a large demand, but also for the purpose of gaining ideas for the production of other fabrics. By the term **cloth analysis** is meant the process of finding all the requirements necessary to reproduce a certain fabric from a given sample. It may not always be desired exactly to duplicate the sample, as certain changes in the weight of the goods, the quality of the material used, etc., are often deemed advisable in order to produce a fabric, seemingly the same, that can be placed on the market at less cost. Thus, a sample of cloth may be given to the designer with instructions either to reproduce the goods exactly or else with certain alterations tending to reduce the cost of the goods without materially affecting the appearance. In the case of a small mill that

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does not regularly employ a designer, this duty is generally performed by the superintendent or boss weaver.

A sample of cloth may be analyzed by several methods, but it is only by the systematic application of some one method derived from a thorough knowledge of the subject that the most economical and advantageous results are obtained. This subject cannot receive too much study, since it is one with which a designer must of necessity be in daily contact. A designer or student of designing should therefore avail himself of every opportunity to analyze such samples of cloth as he may encounter. By this means he will become acquainted with many weaves and color effects and learn to associate them with certain fabrics, thus understanding them much better than it would be possible to understand the bare designs marked out on design paper.

2. In analyzing a sample of cloth the following list of particulars should be found, the desired finished width of the cloth being given, of course, in all cases:

1. Weight of 1 yard, given width
2. Ends per inch in finished cloth
3. Picks per inch in finished cloth
4. Warp pattern (if any)
5. Ends in pattern
6. Ends in warp
7. Patterns in warp
8. Filling pattern (if any)
9. Counts of warp in finished cloth
10. Counts of filling in finished cloth
11. Weight of warp yarn, each color
12. Weight of filling yarn, each color
13. Reed and ends per dent
14. Width in reed, including selvages
15. Weight from loom, including selvages
16. Weave
17. Harness, or drawing-in, draft
18. Chain draft

Many of these items belong to the subject of cloth calculations and therefore will not require any further explanation. In demonstrating the methods of obtaining the other requirements to be found, reference will be made to the same sample of cloth that was used in dealing with the subject of woolen- and worsted-cloth calculations. In addition to the requirements given in the above list there are several of minor importance that should be considered when reproducing a fabric; these, however, will be dealt with later.

WARP PATTERN

3. The **warp pattern** is a requirement that is necessary only when the cloth contains warp yarns of different colors, counts, or materials. There are several methods according to which a warp pattern may be made out. The best is that which employs a diagram to separate the colors, since there is then less liability of confusion and mistakes. In the sample of cloth under consideration the yarns are arranged in the warp 12 ends of brown and 12 ends of white; its pattern is indicated, according to the method above, as follows:

WARP PATTERN

Brown	12		12
White		12	12

Total number of ends in pattern 24

4. As the above is a very simple pattern, a more complicated one will also be taken for the purpose of illustration. Suppose this pattern to be as follows: 1 end of light blue, 1 end of white, 10 ends of dark blue, 1 end of white, 10 ends of dark blue, 1 end of white, 1 end of light blue, 4 ends of slate, 1 end of fancy, 4 ends of slate, 1 end of fancy, 4 ends of slate, 1 end of fancy, 4 ends of slate, 1 end of fancy, 4 ends of slate. The same method is applied to this pattern as to the previous one, thus:

WARP PATTERN

Light blue . .	1						1											2
Dark blue . .			10		10													20
Slate								4		4		4		4		4		20
Fancy									1		1		1		1			4
White		1		1		1												3

Total number of ends in pattern 49

In a pattern like the one given, where there is a repetition of certain combinations of ends in the pattern itself, the representation of the pattern can be reduced as follows:

WARP PATTERN

Light blue	1				1				2
Dark blue			10						20
Slate						4		4	20
Fancy							1		4
White		1		1					3
			2 ×			4 ×			
Total number of ends in pattern									49

The marks 2 × and 4 × indicate that the combinations of ends enclosed with a brace are taken two and four times, respectively. By carefully comparing these two forms the method adopted in the second will be readily understood and it will be seen that both patterns are the same. Another common method of indicating a warp pattern is to arrange the list of colors in the form of a column, enclosing with a brace each portion that is to be repeated and indicating the number of times that the part thus enclosed is to be repeated. With the pattern previously shown this would be as follows:

1 end light blue
1 end white
2 × { 10 ends dark blue
1 end white }
1 end light blue
4 × { 4 ends slate
1 end fancy }
4 ends slate
49 ends in pattern

FILLING PATTERN

5. By the term **filling pattern** is meant the manner in which the filling is inserted in the cloth, either as regards different colors, materials, or counts of yarn. In making out the pattern of the filling of any cloth, it is simply necessary to give the number of picks of each color or count in one repeat of the pattern; this can be shown in the same manner as the pattern of the warp. In case the filling is all of one color, material, and counts, there will of course be no pattern and it will simply be stated as all white, all black, etc., according to whatever color of yarn is used. In the sample of cloth under consideration the filling pattern is exactly the same as the warp pattern, which has previously been given.

DISSECTING, OR PICKING OUT

6. The *weave* is one of the most important particulars concerning a sample of cloth, as without the correct weave it is impossible to reproduce the fabric with a satisfactory resemblance to the original, especially if the fabric has a pronounced weave effect or a color effect depending largely on the weave for the disposition of the color on the face of the cloth. The method of obtaining the weave will require considerable study and practice, although after the weaves of a few samples of cloth have been studied and successfully obtained it will be a comparatively easy matter to obtain the weaves of other samples; in fact, many samples will be met with that will not require much more than a glance to determine the weave. The process of obtaining the weave from a woven fabric is commonly known as **dissecting, or picking out,** although these terms are sometimes applied to the whole process of cloth analysis. The weave obtained from picking out a sample of cloth is often spoken of as a **pick-out.**

By the term **weave** is meant the manner of interlacing the warp and filling, this being shown on design paper by means of filled-in squares, or *risers*, which represent the warp

floating over the filling, and blank squares, or *sinkers*, which represent the filling floating over the warp.

7. When a sample of cloth is to be picked out, the first thing to be determined is the face and back of the fabric and also which system of threads constitutes the warp and which the filling. These two points will be further discussed later, but the importance of determining these particulars before starting to pick out the weave should be mentioned here. If the back of the cloth were taken for the face, the warp ends would be up when in reality they should be down and down when they should be up. On the other hand, if the filling were considered as the warp, a correct pick-out could not be obtained, since filling threads would be marked up on the design paper when in reality, since they are filling threads, they should be left blank; and at the same time the weave obtained would be turned one-quarter way around. In a twilled cloth this latter would have the effect of making the twill run in the wrong direction. After the face and back, and also the warp and filling, have been determined, the sample should be held in such a manner that the face side will be up and the filling will pass from side to side.

8. As the term *picking-out* implies, the operation of finding the weave from a sample of cloth consists in picking out each pick of filling separately and setting down on design paper the manner in which it interlaces with the warp. Thus, if the filling passes under the first warp end, the square on the design paper representing where that end intersects with the pick under consideration will be filled in, showing that the warp end is raised over the filling at that point. If the pick of filling passes over the second warp end, the square on the design paper representing where the second end intersects with the pick of filling will be left blank, showing that the warp is depressed and the filling is on the face of the cloth at that particular point.

9. Preparation of Sample.—Before commencing to pick out the weave, the sample of cloth needs a certain amount of preparation in order to facilitate the operation.

Several ends from the left side of the sample and several picks from the top should be pulled out, after which all loose ends, except those needed to determine the weave, should be cut off. Generally it is sufficient to leave only enough ends for the repeat of the weave, but before cutting them off be sure that enough ends for a repeat have been left. When

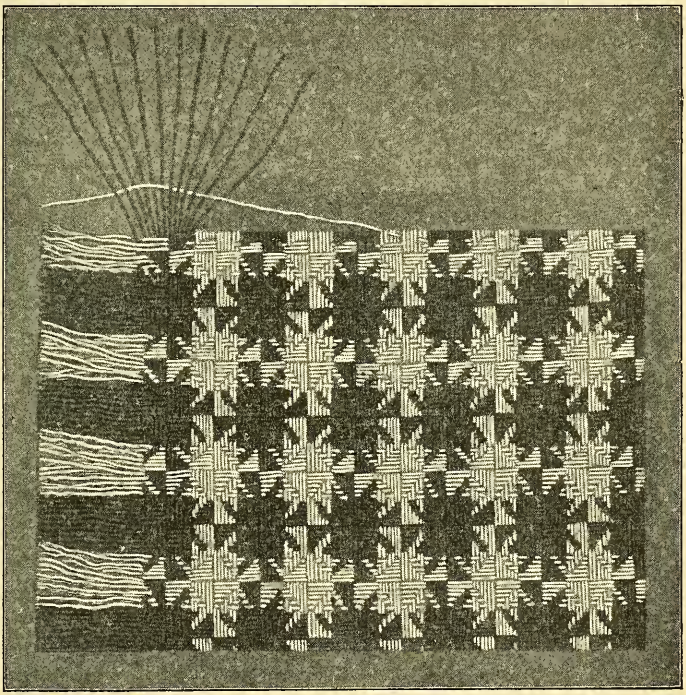


FIG. 1

the preparation of the sample is completed it will have an appearance similar to that shown in Fig. 1, which is a slightly enlarged photographic reproduction of the sample when ready to be picked out.

10. After preparation, the sample should be held in the left hand and laid over the first finger, as shown in Fig. 2, so that when the intersection of each end with the first, or top,

pick has been determined, that end may be drawn under the thumb and held out of the way while determining the intersection of the next end. In this manner it will be possible easily to keep the ends separate and determine the interlacing of each consecutive end with the pick.

For manipulating the ends and picks when determining the interlacings of the weave and when removing the picks from the cloth, an instrument known as a *picking-out*, or

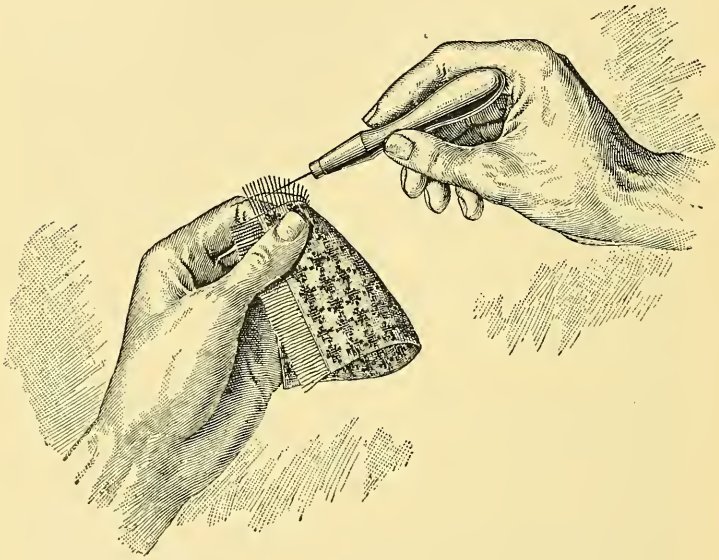


FIG. 2

dissecting, *needle* is used. This consists simply of a stout needle, usually inserted in a wooden handle so that it may be conveniently grasped.

A method that may be used to advantage in many cases is to lay the sample on a white surface if it contains dark-colored yarns, and on a black surface if it contains light-colored yarns. By this means the interlacings and individual threads will stand out much more prominently, especially when working by artificial light. When this method is used,

a *pick glass* will often be of great aid in determining the interlacings of the warp and filling, especially if the sample is woven of fine yarns or if it contains a large number of ends and picks per inch. A **pick glass, or linen tester,** as it is sometimes called, is a simple lens, or magnifying glass, contained in a suitable support; it is also used to enable the number of ends or picks per inch to be counted readily. A pick glass with a field of less than 1 square inch is undesirable for purposes of analysis.

In either method, the top pick should be drawn slightly from the body of the cloth until its interlacings with the ends can be plainly seen. Then commencing with the end of the warp at the left and taking each end in succession, indicate on design paper whether the end is above or below the pick of filling. If the first end is above the pick of filling, it will be represented by a filled square on the design paper; if it is below the pick, the square will be left blank. Proceed in like manner with each end until a repeat is found. It is well to carry the first few picks out two repeats in order to be sure of a repeat of the weave, after which the extra ends may be cut off as shown in Fig. 1.

The interlacings of the first, or top, pick should be placed on the top row of squares on the design paper and the interlacings of the first end, or the end at the left, with the first pick should be placed on the first square at the left on the design paper; that is, the interlacing of the first, or left, end with the first, or top, pick will be shown by the square in the upper left-hand corner of the design paper. It should be understood that the top pick is not the first pick that is put in the loom, although it is the first pick picked out. If the top pick of the weave were the first one put in the loom the weave would be reproduced in reverse order; that is, top for bottom. This being the case, it will be seen that the last pick of the weave removed will be the first pick put in the cloth in the loom; consequently, the lower left-hand corner of the weave, when placed on design paper, is then considered to represent the intersection of the first end and first pick. This is difficult for a beginner to comprehend, but must be

thoroughly understood, since it is an important point when building a harness chain from the draft.

After its interlacings have been found and placed on the design paper, the first, or top, pick should be drawn out of the cloth entirely and the next pick raised among the loose ends, so that its intersections may be found in the same manner as those of the first pick. The intersections of the second pick should be placed on the horizontal row of squares directly below the row of squares on which the intersections of the first pick were marked. After marking the interlacings of the second pick, proceed in a similar manner with the third and each successive pick until a pick is found that interlaces with the warp in the same manner as the first pick. This generally indicates that the weave repeats at this point, but it is a good plan to pick out three or four more picks and compare them with the first ones taken out, in order to be sure that the weave does repeat at this point. These extra picks must be ignored afterwards and only one repeat of the weave used when finding further particulars. When one repeat of the weave is obtained, it represents what is repeated as many times as required in the width and length of the cloth, and is therefore all that is necessary.

Some designers prefer to commence at the bottom of a piece of cloth to pick out. In this case after the interlacings of the first pick have been marked on design paper it is removed from the cloth and the next pick above it is examined and marked on the design paper, but in this case it is set down immediately above the one that was first marked. The interlacings of the third pick taken from the cloth are placed above the second, and so on, so that whether the pick-out is commenced at the top or the bottom of the sample, the final result as shown on design paper will be the same.

11. The best plan of indicating the weave when picking out is to prick with the picking-out, or dissecting, needle the squares that are required to be marked and afterwards mark them with ink or pencil. This method makes it unnecessary

to lay down the picking-out needle and take up the pen or pencil every time a square needs to be marked.

If a sample contains a large number of ends and picks per inch, or warp and filling yarns of the same color, the yarns are liable to become crossed and the wrong end marked on the design paper. To prevent this it is an advantage, before starting to pick out, to place the warp threads in a comb, fastening the ends together between two pieces of paper with mucilage, in order to prevent their slipping back. If the ends are crossed or in the wrong order when placed in the comb, this fact will be noticed before the weave repeats, and by making a note of the places where these crossed ends should be, they may be recopied in their proper order after the repeat of the weave is found. This method will be found useful with cloth difficult to dissect.

It often happens that a certain sample, owing to the large number of warp ends that it contains, is much easier to pick out if the ends are removed from the cloth instead of the picks, but in this case the squares must be filled in for those picks (considered as ends) that are down and left blank for those that are up. Unless this is done the reverse of the weave in the sample will be obtained on the design paper.

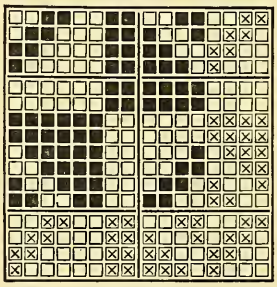
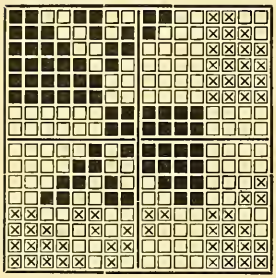


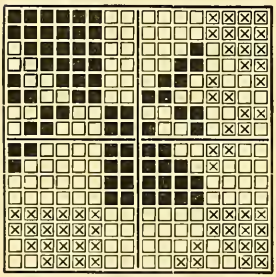
Fig. 3

A good aid when picking out warp-backed and double cloths is to cut the backing ends about $\frac{1}{8}$ or $\frac{1}{4}$ inch shorter than the face ends, after having removed a sufficient number of picks for dissecting purposes. If the fabric is hard-felted or has a nap, singe the sample with a match and with a knife scrape off the fiber, being careful not to injure the body of the yarn. In many cases where weaves are of regular order, as twills or weaves that are very frequently used, it will not be necessary to pick out the weaves, since they will be readily recognized from the appearance of the fabric.

12. In Fig. 3, the pick-out for the cloth sample under consideration is shown. It will be noticed that 4 ends and 4 picks are marked with crosses, while the rest of the weave is filled in solid. These are extra ends and picks that have been picked out, in order to make sure that one repeat of the pattern has been obtained. When greater confidence has been obtained, it will not be necessary to pick out many extra ends and picks in simple weaves. This is desirable, however, in the more complicated weaves. The solid, or filled-in squares, represent one repeat of the weave, which it will be seen is a check weave on 12 ends and 12 picks.



(*a*)



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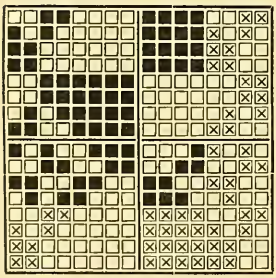

(*c*)

FIG. 4

Several correct but apparently different results might be obtained in picking out a sample of cloth, owing to the fact that the pick-outs might not have been started on the same end or the same pick; in this case each end and pick will be the same in each pick-out, but arranged in different order.

For instance, if the cloth sample had been so prepared that the seventh end of Fig. 3 was the first end at the left of the sample and the top pick of Fig. 3 was still the top pick of the sample, the weave shown in Fig. 4 (*a*) would have resulted. If the sample had been so prepared that it corresponded in its ends to Fig. 3, but the top pick was the tenth pick of Fig. 3, the weave obtained would be as shown in Fig. 4 (*b*). Again, if the sample had been so prepared that the eleventh end of Fig. 3

was the first end of the sample and the fourteenth pick the top pick, the pick-out would have resulted as shown in Fig. 4 (*c*). If these three weaves are examined carefully, it will be seen that although the weaves are apparently different from one another and from Fig. 3, they are all in reality exactly alike, since if repeated several times in the cloth, the same effect will be produced, the difference in their appearance being due only to the end and pick on which the pick-out is started.

After having obtained a pick-out of a greater number of ends and picks than is actually necessary to show one repeat of the weave, it is always best to so select the ends and picks for a repeat that the weave will have the appearance that it naturally would if constructed by a designer. Thus, if one repeat of the weave, as shown by the filled squares in Fig. 3, be compared with one of the weave shown by the filled squares in Fig. 4 (*c*), the lack of a logical and natural arrangement of the weave is very noticeable in the latter as compared with the former. The impression conveyed by Fig. 3 is that the weave is a simple check weave, consisting of four equal sections of 6 ends and 6 picks each. It is also apparent that in the upper left-hand and lower right-hand sections the filling predominates on the face of the cloth, while in the upper right-hand and lower left-hand sections the warp predominates. No such impressions are conveyed by the repeat of the weave as shown in Fig. 4 (*c*), nor is the arrangement of the weave as clear, even in Fig. 4 (*a*) and (*b*), as in Fig. 3. It will thus be seen that there are advantages in selecting the most suitable end and pick as the first end and the first pick of a weave, and especially is this true in weaves that are combinations of two or more simple weaves.

There are several points that may be learned from the weave of the sample under consideration. In the first place, it will be noticed that this weave is an evenly balanced check; that is, the total area of 12 ends and 12 picks occupied by the weave is divided into four areas of 6 ends and 6 picks each. The check is obtained by transposition and cuts perfectly; that is, the warp floats of one section

oppose the filling floats of the adjacent sections and vice versa. When the yarns used are colored as in the sample under consideration, this weave produces what is sometimes known as a *star check*.

It should not be thought that every sample of cloth is made up of a weave design, or combination of weaves, as in the case of this sample; many cloths consist of simply one weave.

HARNESS, OR DRAWING-IN, DRAFTS

13. The **harness draft** indicates the order in which the warp ends are drawn through the harnesses. When making it, each end that interlaces with the filling in a different manner from other ends must be drawn in on a separate harness. As a result, as many harnesses will be required for any given weave as there are ends having different interlacings.

By carefully examining each end in one repeat of the weave obtained from the cloth under consideration, it will be seen that of the 12 ends in the weave all have different interlacings with the filling except the fifth and sixth ends, which are alike, and the seventh and eighth, which are also alike. The fifth and sixth ends, therefore, could be drawn in on the same harness, since they work exactly the same; this is also true of the seventh and eighth ends. But as this would make an irregular drawing-in draft and result in the saving of only 2 harnesses, it is best to draw the warp through the harnesses straight for this fabric. This will make a straight drawing-in draft on 12 harnesses, as shown in Fig. 5.

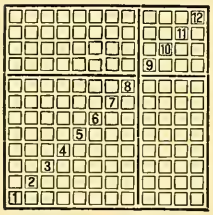

Fig. 5

The horizontal rows of squares in Fig. 5 represent the harnesses, while the figures in the draft show on which harness each end is drawn in. In making out the drawing-in draft, commence with the first end of the weave at the left and draw it in on the first harness. The second end of the weave must in this case be drawn in on a separate harness, as it has different interlacings from the first end, and so is

drawn on the second harness as indicated. Proceed in the same manner with each end of the weave in succession, always working from left to right.

14. If any end in a weave has interlacings exactly the same as the interlacings of any other end in the weave, it may be drawn in on the same harness, in which case the same number of harnesses as ends in the weave will not be required. However, as explained previously and illustrated by the weave under consideration, it is sometimes desirable to use more harnesses than are absolutely necessary, because of the increased simplicity of the drawing-in draft thereby obtained. The drawing-in draft will always occupy the same number of ends as one repeat of the weave, but if more than one end is drawn on any harness it is evident that the same number of harnesses as ends in the weave will not be used.

It should be borne in mind that the color of the ends does not make any difference in the manner of drawing each end through the harnesses, the only distinction being the manner in which the end interlaces with the filling, except that in some cases, where there is a fancy thread in a design, these threads are all drawn on one harness if possible. Many weaves may be drafted down to a very small number of harnesses, but this is not always advisable, as in many cases the draft will become so complicated that the weaver will have considerable trouble in drawing in a broken end on the correct harness. Then, again, if the whole warp is drawn in a small number of harnesses, especially in goods having a large number of ends per inch, the heddles on the harnesses become so crowded that the ends break much oftener, owing to the chafing that results from operating the harnesses when they are crowded. In many cases other circumstances will be found that influence the number of harnesses on which a weave or combination of weaves is woven. A student of designing should constantly seek information on these points, especially in a weave room where there is an opportunity of examining samples of cloth from the various fabrics and of knowing how they are woven. He may then

find, by analysis, the lowest number of harnesses on which it is possible to weave the sample, and also the actual number of harnesses on which it is being woven in the weave room. If more harnesses are used than the lowest number possible, the reason should be learned. With many weaves it will not be possible to tell at a glance the number of harnesses necessary, as was the case with the weave in the sample of cloth under consideration. Such weaves must be carefully examined and the interlacings of each end studied separately, in order to determine which ends have similar interlacings.

15. When making out the harness, or drawing-in, draft for any weave, the following particulars should be noted in each case: (1) It is always desirable to make out a harness draft in such a manner that it will be as nearly a straight draw as possible; this is a great aid to the weaver when drawing in broken ends, as he can thus find the proper harness more readily. (2) Try to have the same number of ends on each harness; this is a great aid to the smooth and easy running of the loom, as it equalizes the strain on each harness. (3) If it is necessary to place more ends on some harnesses than on others, try to have these harnesses at the front, as the majority of broken ends will occur on these harnesses and, if they are at the front, the ends are much more easily tied in. The front harnesses also are easier on the yarn, since they are not lifted as high in shedding as the other harnesses.

CHAIN DRAFT

16. The **chain draft** is obtained from the weave and drawing-in draft, and therefore these must first be obtained. By referring to Fig. 5, which shows the harness draft for the weave under consideration, it will be seen that the first end in the weave is drawn in on the first harness; therefore, the interlacings of the first end must show the working of the first harness; or in other words, the interlacings of the first end show the manner of raising the first harness. The

second end is drawn through the second harness; therefore, the interlacings of the second end as shown in the weave illustrate the manner in which the second harness is raised. The same method is continued throughout, proceeding in regular order, as this is a straight draft. However, where a weave is drafted to a lower number of harnesses than there are ends in the weave, that is, where the drawing-in draft is not straight and more than one end is drawn in on any harness, that harness will control two or more ends of the weave; but in the chain draft only one of these ends will be needed to govern the method of raising the harness. Consequently, when obtaining the chain draft, begin at the left of the weave and take only those ends that are drawn in on different harnesses, taking each end only once. In the weave under consideration, each end is drawn in on a different harness; therefore, each end will have to occur in the chain draft as shown in Fig. 6, which in this case is the same as the weave, or pick-out, in Fig. 3, in consequence of the drawing-in draft being straight. When the harness draft is not straight, the chain draft becomes a reduced weave—reduced according to the harness draft.

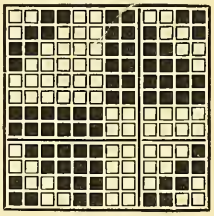

Fig. 6

ADDITIONAL POINTS TO BE DETERMINED BY ANALYSIS

17. In addition to the requirements listed in Art. 2, there are a few other items that must in most cases be determined when analyzing a fabric. Some of these are unnecessary in themselves, but must be ascertained in order that other items may be accurately found. They are as follows: (1) determination of the face and back of the fabric; (2) determination of warp and filling; (3) determination of the direction of twist in warp and filling; (4) the shrinkage of the cloth; (5) the number of beams necessary; (6) the raw material.

DETERMINATION OF FACE AND BACK OF FABRIC

18. The face and back of a fabric must always be decided on before finding the pick-out, in order that the correct weave may be obtained. In most fabrics this is easily done, although some cloths baffle the most experienced designer. The face of a worsted fabric that has a prominent design will be found to show a much clearer and better pattern than the back. The finish on the face side is also better in practically every case, the cloth being generally sheared or singed closer; it will also be more lustrous, since it receives more brushing and attention in the finishing. Often the back of such a cloth will show more or less loose fibers, while the face will be devoid of the same. Often the effect of the weave is such that the face of the fabric is readily determined. When a fabric is a backed or a double cloth, the face can often be distinguished by the style of the finish. The backing yarns in a double cloth are also frequently coarser and of poorer quality than the face yarns. In a filling-backed fabric, the backing filling floats on the back of the cloth and is generally a soft-twisted yarn, in order to give the cloth a warm feeling. Warp-backed fabrics have long floats of the backing warp floating on the back of the cloth, and therefore the face is readily determined.

When a fabric has a stripe design, the stripe usually shows up more prominently and has a more finished appearance on the face of the fabric. In milled and napped fabrics, the face of the cloth is mostly smoother and more lustrous than the back, and the nap is generally brushed in one direction and sheared to an even length, thus making a smooth and velvety surface on the face of the goods.

DETERMINATION OF WARP

19. There are several methods by which the warp may be distinguished from the filling: (1) If the sample submitted for analysis contains a part of the selvage, the warp can be readily distinguished from the filling, since the selvage always runs in the direction of the warp. (2) If in any

fabric one series of yarn is found to be harder-twisted—that is, has more turns of twist per inch—than the other series, the former will in all probability be the warp, because harder-twisted yarns are stronger and it is customary to use them where the most strain occurs, which is always in the warp. (3) If the sample has been gigged and a fairly long nap raised on the cloth, the direction of the nap will always indicate the direction of the warp, since all cloth, in being finished, is passed through the finishing machines in the direction of the length of the piece, or the warp. (4) The counts, or number, of the yarns will often indicate which series of yarn is warp and which is filling, since in many cases the filling will be of finer counts than the warp. However, the student should not assume that this is true in every instance. (5) If in any case one series of yarn is found to consist of threads of different materials, such as worsted and cotton, while the other series of yarn is all of one material, the former is generally the warp, although this is not an invariable rule. (6) If the sample of cloth submitted for analysis contains reed marks, these marks will indicate the warp, since they always run warpway of the goods. They are caused by the reed wires becoming bent or getting out of place, thereby crowding some ends together and giving others too much space. (7) Any fabric of a striped character, such as trouserings, etc., will usually indicate the warp at once, as the stripe nearly always runs in the direction of the warp. (8) If the design is a twill, it generally runs up to the right, thus indicating the warp. This, however, is not an invariable rule, as many cloths are twilled to the left. (9) If one series of yarn is composed of ply yarn and the other series of single yarn, the ply yarn may usually be considered the warp and the single yarn the filling. In woolen cloths, however, ply yarns are frequently used in the filling. (10) In union fabrics in which one series of yarn is all cotton, this series is generally the warp yarn.

DETERMINATION OF TWIST

20. By the term **twist** both the direction of the twist and the amount of twist, or number of turns per inch, placed in the yarn is meant. The direction of the twist of yarn becomes an important matter when reproducing cloth, since with some weaves a different effect will sometimes be obtained by simply changing the twist of the warp or the filling. Yarns may be twisted in one of two directions, which are technically known as *right twist* and *left twist.* There is considerable difference of opinion as to what constitutes a right-twist or a left-twist yarn, as some mills consider as right-twist what other mills consider as left-twist yarn. However, the method of indicating the twist that is most commonly applied will be explained here.

By holding the thread between the thumb and forefinger of each hand the direction of the twist may be easily learned. If, when turning the yarn from the body with the right hand, it is untwisted, it is right-twist; if it is twisted up harder, it is left-twist. Another method of determining the twist of the yarn is to observe which way the twist marks on the surface of the thread are inclined when the thread is held upright. If they slant up to the left, the yarn is left-twist; if up to the right, it is right-twist. This is the method adopted with screws for determining the twist of the screw thread. Fig. 7 represents a yarn that would be known as a right-twist yarn, while Fig. 8 illustrates a left-twist yarn. By closely examining the yarn in the sample under consideration, it will be seen that all the yarn in the warp is a 2-ply yarn twisted to the left, or left-twist, while the filling is a single right-twist yarn. The single yarns twisted for the warp thread would be spun right-twist and when folded would be twisted to the left, since the ply yarns are always twisted in the opposite direction to the single yarns of which they are composed.

Fig. 7

Fig. 8

As previously stated, twist also refers to the amount of twist, or the number of turns per inch, in a given yarn.

In the case of a ply yarn this can usually be readily ascertained by putting the yarn under a pick glass; or it can be found with more accuracy by untwisting a given length of yarn and dividing the number of turns of twist by the number of inches measured.

21. Twist Counter.—The amount of twist in any yarn may be determined by means of an instrument made for the purpose of untwisting the yarn and registering the number of revolutions made in taking out all the twist; this instrument is known as a **twist counter.** The simplest and most commonly used form is shown in Fig. 9. It consists primarily of two jaws, one of which *b* is capable of adjustment on a bar *a*; the other jaw *c* may be rotated, the exact

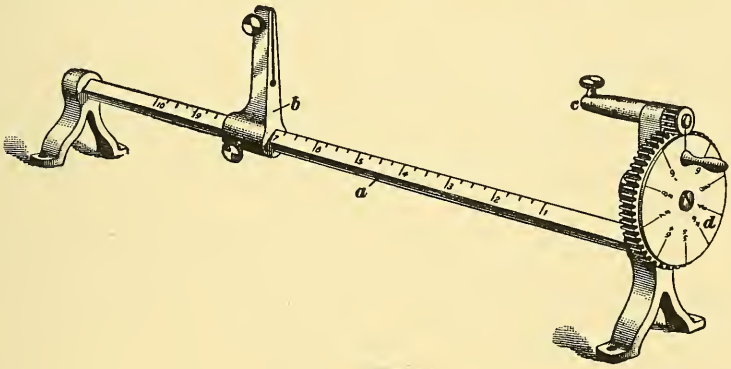

FIG. 9

number of turns that it makes being indicated on a graduated dial *d*. The counter is adapted for finding the number of turns in a sample of yarn from 1 to 10 inches in length, whether right- or left-twist. The yarn is held firmly by the jaws at a given distance apart, as indicated by the position of *b* on *a*; the jaw *c* is then rotated until all the twist is taken out of the yarn, the instrument recording the number of turns on the dial *d*.

SHRINKAGE

22. The shrinkage of the cloth is an item that can be determined only by the experience and the judgment that will come to the student of designing after becoming familiar with various cloths and their peculiarities in finishing.

It must be understood that while it is true that certain goods shrink a given percentage within certain limits, yet there is some leeway, and the finisher can produce goods of any width and weight required within reasonable limits. The shrinkage, of course, varies largely with the raw material as well as with the class of goods; some wools will full up much more quickly than others and thus shrink more. It must be remembered that goods can be shrunk almost any desired amount, depending on the nature of the fabric that is desired.

23. The following table shows the percentages usually allowed for different classes of goods, thus giving an idea of how wide they should be reeded, in order to finish easily to the desired width:

Class of Goods	Percentage of Shrinkage
Beavers	25 to 30
Kerseys	25 to 30
Meltons	25 to 30
Pilots	25 to 30
Doeskins	15 to 20
Cassimeres	12 to 15

Woolen goods shrink more than worsted goods and consequently should be reeded wider and warped longer for the same finished width and length. Goods that are fulled also shrink more than goods that are not fulled. Heavy woolen goods with heavy fulling, such as triple-milled goods, will sometimes shrink as much as 30 per cent. and will average from 25 to 30 per cent. For light-weight, fulled

woolens a shrinkage of from $12\frac{1}{2}$ to 18 per cent. in the width should be allowed, while if not fulled a smaller allowance, say from 10 to 15 per cent., is sufficient. As a general rule goods do not shrink so much in length as in width, especially those that are not fulled, the action in passing through the finishing machinery being to keep the goods stretched in length.

For light-weight worsted goods with a clear finish from 8 to $12\frac{1}{2}$ per cent. shrinkage in width is sufficient to allow, while if fulled (which is rarely done) from $12\frac{1}{2}$ to 15 per cent. should be allowed. For heavy-weight worsted goods with a clear finish from $12\frac{1}{2}$ to 15 per cent. shrinkage in width should be allowed, while if the cloth is fulled an allowance of 15 to 20 per cent. should be made.

Goods made with cotton warps do not shrink in length, and those with cotton filling do not shrink in width, to so great an extent. Goods with a mixture of cotton and wool, either in warp or filling or both, shrink proportionately less than goods made from pure wool. When it is desired to estimate the shrinkage of a fabric from a small sample, a thread of a given length, say 2 inches, may be pulled out, moistened a little, and then stretched (but not too hard) and measured again. The amount that the thread stretches will give some indication of the amount that the fabric has shrunk. This may be done with both warp and filling.

NUMBER OF BEAMS REQUIRED

24. Although the majority of cloths are woven from one beam, yet in many cases, when desiring to reproduce a fabric, it will be found necessary to use more than one beam for the warp yarn, in order to allow for the difference in the take-up of a portion of the warp yarn. When dissecting any cloth, in order to decide this, the weave should be carefully considered. If the cloth is made from one regular weave and the warp yarn is all the same, it will be necessary to use only one beam; but in cases where two or more weaves are combined in a fabric, it will be necessary to study the

weaves carefully and ascertain whether one will take up more than the other.

When desiring to find the number of beams necessary to weave any sample of cloth, the most essential point to notice is the interlacings of each weave. For instance, the ends of one weave may interlace with the filling six times in a certain number of picks, while the ends of another weave in the same design may interlace twelve times in the same number of picks. When such is the case, the ends that interlace the larger number of times will, of course, take up faster, owing to the fact that they bend around the filling more times. If a warp for a cloth like this is placed on one beam, those ends that take up more rapidly will grow tighter in the fabric, thus giving it a cockled appearance. In such instances it will be found best to separate the ends that do not take up alike and place them on two beams. It is unnecessary to use two beams, unless there is a marked difference in the take-up, since small differences will be overcome by the elasticity of the yarn.

In some cases a cloth may be regular, therefore apparently requiring only one beam, with the exception that at certain intervals there will be a fancy thread that will have different interlacings from the body of the cloth, in order that it may produce some desired effect. In this case the fancy threads are placed on a separate beam or, if there are only a few, they are wound on a jack-spool, which may be adjusted at the back of the loom.

Double cloths and cloths backed with warp often require two beams, one for the face warp and one for the back warp, since the back weave is generally different and also because coarser yarns are used for the back of the fabric. If the same yarn and weave are used for the back as for the face of a double cloth, both warps can be put on one beam.

DETERMINATION OF RAW MATERIAL

25. In many fabrics there will be a mixture of different materials; for instance, woolen and cotton yarns, worsted and cotton, woolen and silk, worsted and silk, and other

combinations are often found in the same fabric. In such cases it will be found necessary to determine which ends are of one material and which ends are of another. A knowledge of the different fibers is of great aid in determining of what material various yarns are made, but often a single yarn may be composed of several materials, the mixture having been made in the raw stock. In this case chemical or microscopical tests must be used, in order to determine the different materials and the percentage of each.

The quickest, and an invariable, method of ascertaining whether a sample is composed of animal or vegetable fibers is to burn a sample of the yarn. Vegetable fibers are composed of carbon, hydrogen, and oxygen, and when burned will make a flame and leave a white ash, but will emit no odor. Animal fibers are composed of the same elements as vegetable fibers, but also contain nitrogen and, in the case of wool, sulphur to a small extent; when burned, they will not flame but smolder, coiling up and forming a small, crisp globule. They are also distinguished from the vegetable fibers by the peculiar odor, similar to that of burned horn or feathers, that they emit while burning.

26. Distinguishing Woolen From Worsted Yarn. To distinguish a woolen yarn from a worsted yarn, untwist the yarn and observe the disposition of the fibers in the structure of the thread. A worsted yarn is a thread composed of wool, the fibers of which lie smoothly in the direction of the thread and are parallel to each other. The surface of a worsted thread is comparatively smooth and the thread generally has a well-defined luster. A woolen yarn is also a thread spun from wool, but the individual fibers are mixed and crossed in every conceivable direction and the surface of the thread presents a uniformly rough appearance, which, however, is lacking in luster.

As a further test in distinguishing between woolen and worsted yarns, the length of the fibers that compose the thread may be observed. Fibers from a woolen yarn are usually quite short, while those from a worsted yarn are

longer. This test alone gives not sufficient data on which to base an authoritative statement, because some woolen yarns are composed of rather long fibers, while certain worsted yarns are made of comparatively short fibers; it serves, however, as a further indication to supplement the deductions of other tests. The woolen fiber is also crinkled and curled, while the fiber in a worsted thread has a straight appearance.

27. Distinguishing Silk From Other Yarns.—Silk can generally be distinguished from either cotton, woolen, or worsted by its incomparable luster, and also by the fact that it is generally finer. However, mercerized cotton, which also has a remarkable luster, should not be confounded with silk. These two yarns may be distinguished by burning, as the silk, being an animal fiber, will burn similarly to wool.

28. Distinguishing Linen From Cotton.—Linen may be distinguished from cotton from the fact that the thread is rougher and contains uneven bunches. Linen may also be distinguished from cotton from the fact that it has a harsher feeling.

29. Ascertaining the Percentage of Each Material in Union Fabrics.—Tests have been given by means of which it should be possible to distinguish the fibers that are ordinarily met with in textile fabrics, but nothing has been said about the quantity. Where different materials are placed in a fabric in solid threads of each material it is a simple matter to determine the amount of each material, but when the different materials are mixed in the raw stock it is more difficult to find the exact percentage of each. For instance, many woolen yarns, especially warp yarns in low-grade goods, contain cotton, which not only cheapens the fabric, but makes the yarn stronger. To determine the percentage of cotton, or other vegetable fibers, in a mixed yarn composed of animal and vegetable fibers, the following method may be employed: If accurate results must be obtained, the yarn or cloth sample in which the percentage

of wool and cotton, or other animal and vegetable fiber, is to be determined should first be stripped of dye stuff by being boiled in dilute hydrochloric acid. The yarn or cloth is then immersed for 20 minutes in ammoniacal copper oxide or concentrated sulphuric acid, which destroys the vegetable matter. The fibers that are left when dried and weighed will give the percentage of wool, or other animal fiber, as compared with the weight of the original sample.

30. A method that is used perhaps more frequently than the above is to boil the weighed sample in an 8° B. solution of caustic potash for 2 hours, after which it is washed and dried. During the boiling, a few drops of water are added from time to time to prevent the alkali from becoming too concentrated. After the sample is dried, its weight will be that of the cotton in the sample and the loss in weight will be that of the wool. Instead of potash, a 7° B. solution of caustic soda may be used, the boiling being carried on for not over 15 minutes.

NOTE.—B. means Baumé and refers to the graduated scale on Baumé's hydrometer used for determining the density of a solution.

31. To separate silk, cotton, and wool: Take two samples each of the same weight; boil them from 15 to 30 minutes in a 3° B. solution of hydrochloric acid to remove the sizing, etc.; then wash them. Immerse one sample in a boiling solution of basic zinc chloride for a short time; then wash thoroughly first in acidified and then in clean water, and dry it. The loss in weight gives the amount of silk. Boil the second sample for 15 minutes in a 7° B. solution of caustic soda and then wash and dry it. The residue is cotton, to the air-dry weight of which must be added about 5 per cent. to compensate for the loss of the fiber during the operation. The difference between this and the original weight represents the weight of wool.

TWILL WEAVES AND DERIVATIVES

Serial 506 Edition 1

TWILL WEAVES

GENERAL CONSIDERATION

1. Introductory.—Certain weaves, because of the similarity of their construction and of the effects that they produce in the fabric, are grouped in classes. They partake of the nature of fundamental, or standard, weaves, not only on account of the simplicity of their construction, but also because of their wide and varied use in almost every class of textile fabrics. For instance, the plain weave may be considered as a standard construction, since it is widely used in weaving fabrics composed of any material. One of the largest of these classes is that of **twill weaves,** which are so called because of the peculiar effect they form on the surface of the fabric. Many of the simpler twills have, like the plain weave, acquired distinctive names by which they are readily recognized by experienced designers.

2. Construction of Twills.—In the plain weave, each end is alternately raised and lowered, but in a twill the warp ends are so raised that the warp and filling floats form diagonal lines across the cloth, known as *twill lines.* In a twill each warp end must be either over or under the filling for at least 2 picks in succession and at least 2 successive warp ends must be raised or lowered on each pick, in order to make the twill line across the cloth. On this

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account at least 3 harnesses are necessary to weave a twill, or in other words three is the smallest number of harnesses on which a twill effect can be formed in the cloth. Thus, the *3-harness*, or *prunelle*, *twill*, as it is called, is the simplest twill that can be made.

As shown in Fig. 1, the first end of this weave is down on the first pick, but floats over the second and third picks; the second end is down on the second pick but floats over the third and first picks; the third end is down on the third pick but floats over the first and second picks. Each end in this weave therefore floats over 2 picks in succession. This constitutes one repeat of the weave; that is, if the fourth end were shown, it would be found to be similar to the first end, while the fifth end would be like the second, and the sixth like the third. It will also be noted in Fig. 1 that on the first pick the second and third warp ends are raised, on the second pick the first and third warp ends are raised, and on the third pick the first and second warp ends are raised. Thus it will be seen that in this weave all the requirements of a twill weave are met. With this weave a twill, or diagonal, line is formed running up to the right. Weaves may be twilled either to the right or to the left, although in the majority of cases they are so constructed as to form twill lines running up to the right, as in the case of Fig. 1. Fig. 2 shows a warp-flush prunelle twill running to the left.

Fig. 1

Fig. 2

Fig. 3

3. A weave may be *warp flush*, *filling flush*, or *equally flush*, depending on whether a preponderance of warp or filling or an equal amount of each is brought to the face of the cloth; thus, Fig. 1 is a warp-flush prunelle twill, while Fig. 3 shows a filling-flush prunelle twilled to the right and Fig. 4 shows a filling-flush prunelle twilled to the left. A cloth woven with a warp-flush weave shows a filling-flush weave on the back, and if woven with a filling-flush weave shows a warp-flush weave on the back. Thus it will be seen that these terms simply refer to the effect on the face of the cloth.

Fig. 4

4. Repeat of the Weave.—One of the most important things in designing and probably one of the most difficult for the beginner to understand is the repeat of the weave; especially is this of importance in dealing with twills. It will be found a great aid, when only one repeat of a weave is given, to practice extending the weave on design paper for several repeats. By this means one repeat of any weave will more readily be found when it becomes necessary to distinguish a single repeat from several repeats. Weaves may be repeated on design paper either in their ends or in their picks, or they may be repeated in both the ends and the picks. Suppose, for example, that it is desired to extend Fig. 1 for three repeats in its ends. As already stated, this weave is complete on 3 ends; consequently, three repeats will occupy three times this number, or 9 ends. If it is desired to repeat the weave in its picks three times, it will occupy 9 picks; while if it is repeated three times in both ends and picks, it will occupy 9 ends and 9 picks.

FIG. 5

When repeating a weave it is simply necessary to copy the weave exactly as it is; that is, if Fig. 1 were to be repeated in its ends, one repeat of the weave would first be set down and the other repeats copied. The fourth end would be the same as the first; the fifth end, the same as the second; and the sixth end, the same as the third. This would make two repeats. If another repeat is required, the ends will simply be copied again in their proper order. If the weave is to be repeated in its picks, the picks will be copied in the same manner as were the ends when repeating in its ends. Fig. 5 (*a*) shows the weave Fig. 1 repeated three times in its ends; Fig. 5 (*b*) shows the weave repeated three times in its picks; and Fig. 5 (*c*) shows the weave repeated three times in both ends and picks.

REGULAR TWILLS

5. Regular twills are those that run in regular order; it is, therefore, simply necessary to know the interlacing of any one end or pick, say the first, of a regular twill in order to show the entire weave on design paper.

The interlacings of the first end or pick of any regular twill are conveniently shown by writing numbers above and below a horizontal line; thus, for example, $\frac{2\ 1}{3\ 2}$ shows that the first end is up 2 picks, down 3, up 1, and down 2. The interlacing of a regular twill weave shown in this manner is called the *base* of the twill. Since in regular twill weaves the ends interlace with the picks in exactly the same manner as the picks interlace with the ends, the base also shows the interlacing of the first pick, as it indicates that on the first pick the first 2 ends are up, the next 3 are down, the next 1 is up, and the next 2 are down. The sum of these numbers, eight, shows that the twill repeats on 8 ends and 8 picks.

Suppose that it is desired to show the $\frac{2\ 1}{3\ 2}$ twill on design paper. The first step is to mark the first end or first pick in the manner indicated by the base; the twill will be the same whichever is marked. If the first end is marked, it should be marked from top to bottom; if the first pick, it should be marked from left to right. One method, however, should be adopted; consequently, the system of marking the first pick will be used here. Marking this pick shows that the first 2 ends are up, the next 3 ends down, the next end up, and the next 2 ends down, as shown in Fig. 6. The next step is to run up the twill in regular order; that is, if an end is up on one pick, on the next pick the next end in the direction in which the twill is to run is up.

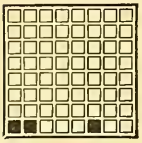


Fig. 6

That this method of making a twill may be more readily understood, each end will be run up separately and afterwards the complete design will be shown. Commencing with the first end and the first pick, which is at the lower left-hand corner, this first end is raised on the first pick; then

on the next pick the next end to the right, if the twill is run to the right, will be raised; that is, the second end will be raised on the second pick, and the third end will be raised on the third pick. This is continued for the 8 ends and 8 picks with the result shown in Fig. 7.

Next taking the second end and dealing with it in exactly the same manner will give the result shown in Fig. 8. It should be noted in connection with this figure that when running these marks up on the design paper the eighth end is raised on the seventh pick. If this were continued in a regular line for the 8 picks, the next mark would come on the ninth end, but the weave is complete on 8 ends; consequently, the mark for the ninth end is placed on the first end, since the ninth end will be the first end of the next repeat, which of course is exactly like the first end of the repeat under consideration. That this is correct will be seen if two repeats of the weave are made.

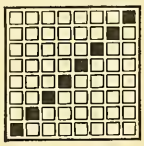


Fig. 7

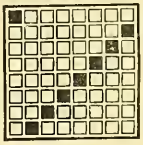


Fig. 8

In Fig. 6, the third, fourth, and fifth ends are lowered on the first pick; these blank squares will consequently run up in the same manner as the filled-in squares, but it is not necessary to consider them since, if the filled-in squares are run up correctly, the blank ones must be correct. Since the sixth end is raised on the first pick, the seventh end will be raised on the second pick and so on, as shown in Fig. 9. It should be noted that the eighth end is raised on the third pick and that in order to continue for the 8 picks, the first end must be raised on the next pick and the marks run from this point to complete the 8 picks, as shown. As the seventh and eighth ends are down on the first pick it is not necessary to consider these. If Figs. 7, 8, and 9 are combined, the complete twill will be obtained, as shown in Fig. 10. When constructing a twill, it is not necessary to run up each twill line

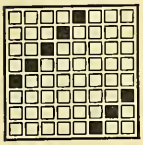


Fig. 9

Fig. 10

separately as in Figs. 7, 8, and 9 and then combine them as in Fig. 10 since it is perfectly feasible to construct the entire twill as shown in Fig. 10 at one operation. The method of running up each twill line separately is adopted only to explain the construction of the complete twill.

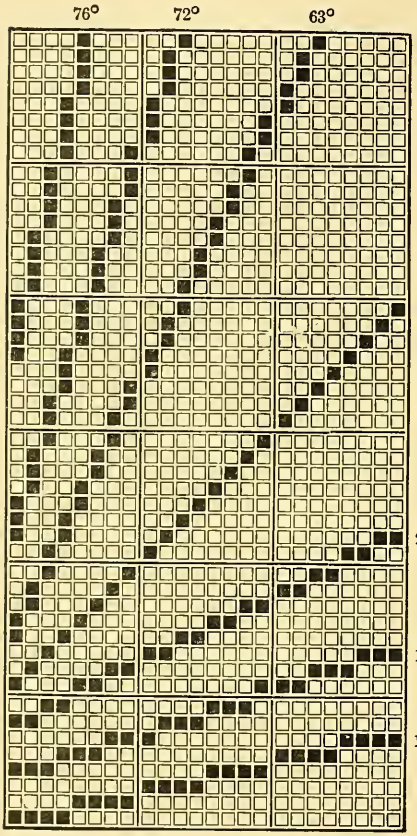


Fig. 11

6. A rule for making any regular twill when the interlacings of the first pick are given is as follows:

Rule.—*Mark on the first pick of the weave the ends that are to be lifted on that pick; then above on the second pick place similar marks, moving them one square to the right if the twill is to run to the right, or one square to the left if the twill is to run to the left. Proceed with each pick in the same way, moving one to the right or left, as the case may be, until there are as many picks as ends, when the weave will be completed.*

7. Angles of Twills.—The angle of a twill is affected: (1) by the manner in which the ends and picks interlace; (2) by the relative number of ends and picks per inch.

Fig. 11 illustrates the method of running up twill lines on design paper so as to form different angles.

In the first twill line at the bottom, the twill moves four squares filling way, or across the design, and then one square up; by this means an angle of 14° is formed. In the next case the twill moves three squares filling way and then one square warp way, forming an angle of 18°. In the next case the twill moves two squares filling way and then one warp way, which gives an angle of 27°. By carefully noting each twill line, the method of forming different angles will be readily understood. Twills are spoken of as being such a degree twill, the 45° twill being the most common, as it is the angle formed by all regular twills.

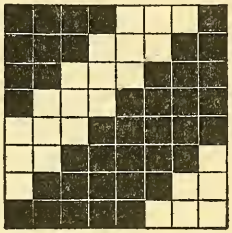


Fig. 12

A twill that forms a certain angle on regular 8 × 8 design paper will not form that same angle in the cloth unless the number of ends and picks per inch and the counts of the warp and filling yarns are the same. For example, the 45° twill shown in Fig. 12 is shown on 8 × 8 design paper; that is, the design paper has eight vertical rows of squares and eight horizontal rows in the same distance, warp or filling way. Since a row of squares across the paper represents a pick and a row of squares vertically represents a warp end, a twill or any design on this kind of design paper shows the weave as it would appear in the cloth if the same number of picks per inch as ends per inch is inserted. Suppose that twice as many picks are placed in 1 inch of the cloth as there are ends per inch; then in order to give a correct representation of this on design paper, a paper should be used that contains twice as many horizontal rows of squares in a given space as it has vertical rows of squares. Fig. 13 shows the twill in Fig. 12 on design paper of this kind; it will be noticed that an angle of 27° is formed. On the other hand, if there are twice as many ends per inch in the cloth as there are picks, an angle

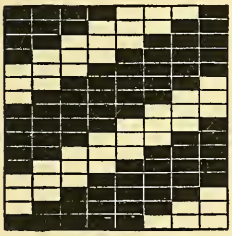


Fig. 13

of 63° will be formed with this same twill; Fig. 14 illustrates this point. It will be noticed that in both Figs. 13 and 14 two repeats of the weave are shown. Ordinarily, however, 8 × 8 design paper is used in constructing designs even if the fabric is to be woven with more picks than ends per inch or vice versa. It is only in jacquard designing and for some

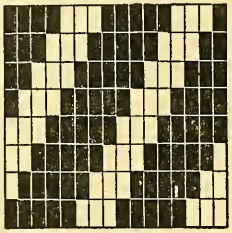


Fig. 14

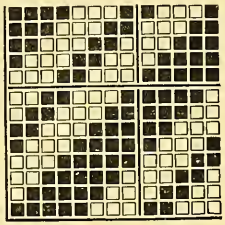


Fig. 15

special fabrics where it is desired to preserve the symmetry of a figure, or pattern, that a design paper is used corresponding to the relative number of ends and picks per inch in the fabric.

When working out twill weaves on design paper it should be understood that whatever kind of twill the weave may be, the

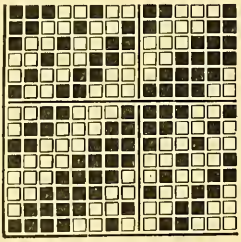


Fig. 16

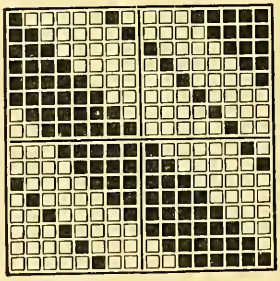


Fig. 17

marks or blanks for one repeat should not be extended beyond the number of ends and picks that has been decided on. For instance, if one repeat of the weave occupies 4 ends and 4 picks, the fifth end would be like the first, and so on; also the fifth pick would be like the first pick, and so on. Consequently, to

show one repeat only 4 ends and 4 picks are necessary. All regular 45° twills repeat on the same number of picks as ends, so that if the base of such a twill occupies 12 ends, it repeats on 12 ends and 12 picks. Twills that form an angle of more than 45° are known as *upright twills*, while those that form an angle of less than 45° are called *oblique*, or *reclining*, *twills*.

(a)

(b)

(c)

(d)

(e)

(f)

(g)

FIG. 18

8. By carefully studying the following regular 45° twills and the explanations previously given, a good understanding of the method of working out twills may be obtained. Fig. 15 is a regular 45° twill $\frac{5}{3}\frac{2}{3}$ twilled to the right; Fig. 16 is a regular 45° twill $\frac{4}{2}\frac{1}{2}\frac{2}{3}$ twilled to the right; Fig. 17 is a regular 45° twill with the base $\frac{1}{5}\frac{6}{4}$ twilled to the left. Several twills that are constantly used in the construction of the more common fabrics are known by definite names. Among them are the *filling-flush prunelle*, Fig. 18 (*a*); the *warp flush prunelle*, Fig. 18 (*b*); the *cassimere*, Fig. 18 (*c*); the *filling-flush crow*, Fig. 18 (*d*); the *warp-flush crow*, Fig. 18 (*e*); the *filling-flush Albert twill*, Fig. 18 (*f*); the *warp-flush Albert twill*, Fig. 18 (*g*); the *filling-flush broken crow*, Fig. 19 (*a*); the *warp-flush broken crow*, Fig. 19 (*b*); the *Venetian twill*, Fig. 19 (*c*); and the *Mayo*, or *Campbell*, *twill*, Fig. 19 (*d*). The weaves shown in Fig. 19 are not regular twill weaves but are weaves that are well known.

(a)

(b)

(c)

(d)

FIG. 19

EXAMPLES FOR PRACTICE

1. A regular 45° twill is arranged $\frac{2}{1}\frac{1}{2}\frac{3}{1}$; show the complete weave on design paper.

2. State what angle the above twill would form in the cloth if woven with 54 ends and 27 picks per inch, using the same counts of warp and filling.

3. Show two repeats in both ends and picks of a regular 45° twill having the first pick arranged $\frac{3}{3}\frac{1}{1}$.

4. State what angle the twill given in answer to question 3 would form in the cloth if woven with 30 ends and 60 picks per inch, using the same counts of warp and filling.

DERIVATIVES OF TWILL WEAVES

9. Derivatives Formed by Rearranging Ends or Picks.—The number of what may be termed fundamental weaves is comparatively small, but the weaves that may be derived from them are innumerable. Thus, if a simple twill weave is shown on design paper, several other weaves may be obtained from it by rearranging either the ends or the picks. Designs thus obtained are termed **derivatives.**

To illustrate how derivative weaves are obtained, a regular 45° twill, Fig. 20, is taken and three other weaves formed from it. Suppose that it is desired to form a derivative weave by rearranging the ends of Fig. 20 in 1, 4, 7, 2, 5, 8, 3, 6 order; that is, the first end of the new weave is to be like

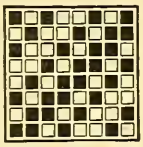


FIG. 20

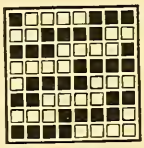


FIG. 21

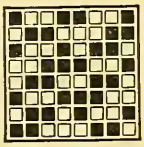


FIG. 22

the first end in Fig. 20, the second end of the new weave like the fourth end of Fig. 20, the third end like the seventh, the fourth like the second, and so on. It will be seen that commencing with the first end of Fig. 20, every third end is taken until by this method the first end is reached again, when the design commences to repeat. Fig. 21 shows the twill in Fig. 20 rearranged in this order.

Suppose that it is desired to arrange the ends in the twill in Fig. 20 in 1, 2, 5, 6, 3, 4, 7, 8 order. Fig. 22 shows that the first and second ends are like the first and second ends in Fig. 20; that the third end is like the fifth in Fig. 20; the fourth is like the sixth; the fifth like the third, and so on.

These two examples show that a number of weaves may be obtained from a regular twill weave, or in fact from any weave. After deriving a weave from a twill still other weaves may be obtained by rearranging the ends of the derivative.

When a weave is to be rearranged in its picks, the same process is employed as when rearranging the ends. Suppose, for example, that it is desired to rearrange the picks of Fig. 20 by taking the first 3 picks, missing the next 3, taking the next 3, and so on until the weave repeats. Fig. 23 shows the twill in Fig. 20 rearranged in this manner; the first 3 picks of Fig. 20 are copied for the first 3 picks of Fig. 23; the next 3 picks of Fig. 20 are skipped; the next 3, that is the seventh, eighth, and first, are copied for the fourth, fifth, and sixth picks of Fig. 23; and so on until the weave repeats.

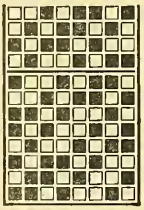


Fig. 23

In rearranging any weave in either its ends or picks, the repeat becomes an important matter and should always be carefully considered. Taking, for example, Fig. 23, it will be noticed that the first pick of this figure is like the first pick of Fig. 20, and also that in working out this new weave the sixth pick of Fig. 23 will be the same as the first pick, but the weave does not repeat on this pick, since the next pick, the seventh, is not like the second. However, after working out 12 picks, the weave repeats, since the next, or thirteenth, pick is like the first, the fourteenth like the second, the fifteenth like the third, and so on.

10. In selecting an order by which to rearrange either the ends or the picks of a weave, care should be taken to select one that will cause the weave to repeat correctly. For example, suppose that it was attempted to rearrange the ends of an 8-end twill by moving in twos; that is, taking one and skipping one; the order would be 1, 3, 5, 7, when it would come back to 1 again and continue in the same order. This, of course, would be a repeat in a certain sense of the

word but would not be a repeat of the weave, since all of the ends of the original weave would not be used.

When it is desired to learn in what order the ends may be taken to make the weave repeat when rearranging the ends or picks of a weave by means of taking one end and skipping a certain number, find two numbers that, when added together, will equal the number of ends or picks on which the weave is complete but that cannot be divided into each other or into the number of ends or picks of the weave without a remainder. When twills are rearranged in this manner they are said to be rearranged in *satin order*.

Suppose that it is desired to rearrange the ends of a twill that is complete on 12 ends and 12 picks. It will be seen that 7 and 5 are two numbers that cannot be divided into each other or into 12 without a remainder but that when added together will equal 12. Therefore, the ends of the weave may be rearranged by moving in sevens or fives. That is, if the ends are arranged on a base of 7, the first end of the weave is copied, while the next six are missed, and so on, which will give the following order: 1, 8, 3, 10, 5, 12, 7, 2, 9, 4, 11, 6; here the weave will commence to repeat and consequently will not need to be continued. On the other hand, take two numbers such as 8 and 4; these added together make 12, but it will be noticed that 4 can be divided into 8 and also into 12. It would not therefore be possible to rearrange a 12-end twill with either of these numbers. To show that this is correct suppose that it is attempted to rearrange the ends of a 12-end weave on a basis of 4, that is, taking the first end and missing the next 3 ends. The order will be 1, 5, 9, and if the next 3 ends are missed it will be seen that it is necessary to take the first end again, when exactly the same ends will be taken, and consequently only these 3 ends will be used, which will not give a repeat of the weave.

11. Derivatives Formed by Combining Twills. Another method of obtaining derivative weaves and one quite generally adopted is that of combining two weaves either in their ends or picks. Suppose that from the two

weaves shown in Figs. 24 and 25 it is desired to form a new weave by combining them pick and pick; that is, first taking a pick of one weave and then a pick of the other, as in Fig. 26. It will be noticed that the first pick of Fig. 26 is the first pick of Fig. 24; the second pick of Fig. 26 is the first pick of Fig. 25; the third pick of Fig. 26 is the second pick of Fig. 24; the fourth pick of Fig. 26 is the second pick of Fig. 25. This is continued until the picks in both Figs. 24 and 25 are all used, when the weave will be complete.

FIG. 24

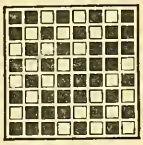


FIG. 25

There are numerous other weaves that may be obtained by combining these two weaves pick and pick. Take for example Fig. 27, which is different from the weave shown in Fig. 26 and yet is obtained by combining Figs. 24 and 25 pick and pick. By carefully noticing Fig. 27, it will be seen that in this case the second pick of Fig. 25, instead of the first, is the first pick taken, as was the case with Fig. 26. Thus, the first pick of Fig. 27 is the first pick of Fig. 24; the second pick of Fig. 27 is the second pick of Fig. 25; the third pick of

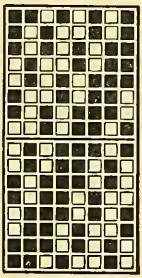


FIG. 26

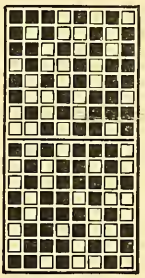


FIG. 27

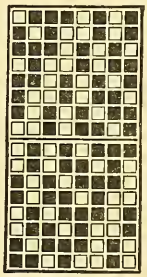


FIG. 28

Fig. 27 is the second pick of Fig. 24; the fourth pick of Fig. 27 is the third pick of Fig. 25; and this is continued until all the picks in both weaves are used, when the new weave will commence to repeat.

Still another weave may be obtained by commencing with the first pick of Fig. 24 but having for the second pick of the new

weave the third pick of Fig. 25. Fig. 28 shows such a weave, and by carefully studying each pick it will be noticed that the first pick of Fig. 28 is the first pick of Fig. 24; the second pick of Fig. 28 is the third pick of Fig. 25; the third pick of Fig. 28 is the second pick of Fig. 24; the fourth pick of Fig. 28 is the fourth pick of Fig. 25; the fifth pick of Fig. 28 is the third pick of Fig. 24; the sixth pick of Fig. 28 is the fifth pick of Fig. 25; and so on until all of the picks in both Figs. 24 and 25 are used, whereupon the weave commences to repeat.

In addition to combining weaves pick and pick, they may also be combined by taking 2 picks of one weave and 1 pick of the other or by taking 2 picks of one weave and 2 picks of the other; or in short, almost any method may be adopted, and consequently the number of weaves that may be obtained is almost without a limit. Weaves should be combined in such a manner that long floats of either warp or filling will be avoided. If the combining of different weaves is practiced, it will be seen that frequently when two weaves are combined by one method long floats will appear, but that by starting on a different pick or by using a different method of combination the same two weaves may be combined without this defect.

12. When combining or copying twills, the natural tendency is to look from the designs to be copied to the design being made; this method occupies considerable time and is liable to cause errors. A better method is to mark the first pick of the twill and then run it up in the same manner as regular twills. When two twills are to be combined in their picks, it is a good plan to indicate on the design paper the picks on which one twill is to be placed and then run up each twill separately, placing each on its own picks.

Though the two weaves that have been combined are complete on the same number of ends and picks, yet it frequently occurs that weaves are combined that are not complete on the same number of ends and picks; in these cases it is important to know when the weave formed by the combination commences to repeat. To illustrate this point, suppose

that it is desired to combine pick and pick an 8×8 twill with a 6×6 twill. When the 8 picks of the first weave have been used, all 6 picks of the second weave will have been used once and in addition 2 of them will have been used the second time; therefore, the weave will not repeat here. When the 8 picks of the first weave have been used twice, the 6 picks of the second weave will have been used twice and 4 of them the third time; therefore, the weave does not repeat as yet. When the 8 picks of the first weave have been used three times, all the picks of the second weave will have been used exactly four times, and consequently the weave will repeat at this point. Thus the first weave will be repeated in its picks three times, making 24 picks, and the second weave will be repeated four times, making 24 picks, and since these two weaves are combined pick and pick the resulting weave will occupy 48 picks.

On the other hand, 24 ends will be occupied by the resulting weave in order to have the weave repeat in its ends. Therefore, any weave formed by combining pick and pick an 8×8 twill with a 6×6 twill will occupy 24 ends and 48 picks before it will commence to repeat. In other words, weaves when combined pick and pick will occupy a number of ends equal to the least common multiple of the number of ends on which each individual weave is complete, and a number of picks equal to twice the least common multiple of the number of picks in one repeat of each of the original weaves. In the above example the least common multiple of 8 and 6 is 24; therefore, the completed weave, as stated, will occupy 24 ends and $2 \times 24 = 48$ picks.

13. Derivative weaves are also formed by combining the ends of two weaves. The principles governing the combining of twills in their picks, also govern this case. Figs. 29 and 30 show two twills that it is desired to combine in this manner. Since they occupy a different number of ends, both the method of combining twills end and end and the method of determining the repeat of a weave formed by combining twills that occupy a different number of ends or picks will be

understood. Fig. 29 occupies 10 ends, while Fig. 30 occupies only 5 ends; consequently, Fig. 30 must be repeated twice in its ends in order to have it occupy the same number of ends as Fig. 29. It must also be repeated twice in its picks in order to have it occupy the same number of picks as Fig. 29. When Fig. 30 has been repeated in both ends and picks it will occupy 10 ends and 10 picks; there will then be two weaves each occupying 10 ends and 10 picks that are to be combined end and end. Consequently, the resulting weave will occupy 20 ends and 10 picks. If these two weaves were combined pick and pick, the resulting weave would occupy 10 ends and 20 picks.

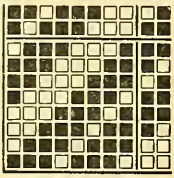


Fig. 29

Fig. 30

Fig. 31 shows the weave obtained by combining Figs. 29 and 30 end and end, commencing with the first end of Fig. 29 and the second end of Fig. 30. It will be seen that the first end of Fig. 31 is the first end of Fig. 29; the second end of Fig. 31 is the second end of Fig. 30; the third end of Fig. 31 is the second end of Fig. 29; the fourth end of Fig. 31 is the third end of Fig. 30; and so on until the weave repeats. It will be noticed that when all the ends of Fig. 30 have been used once they are used the second time in regular order to make the weave repeat.

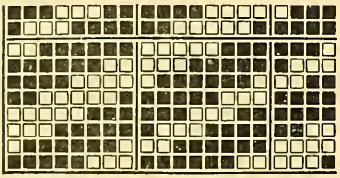


Fig. 31

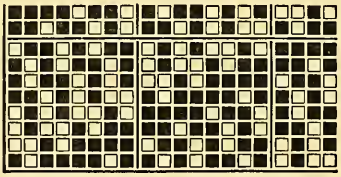


Fig. 32

Fig. 32 shows another weave formed by combining Figs. 29 and 30 end and end. In this case the first end of Fig. 29 is the first end of that weave taken, while the fifth end of Fig. 30 is the first end of that weave taken. Since the principles of producing different weaves when combining them pick and pick apply equally well to combining weaves end and end,

the number of different weaves that it is possible to produce by this method is as varied as the number that may be obtained by combining weaves in their picks. Moreover, the weaves that are combined may be rearranged in either their ends or picks after the manner described and then combined, etc., so that the number of weaves that may be obtained in this manner is almost without limit.

When twills are combined the angle is changed. Thus, if two regular 45° twills are combined end and end they form a 27° twill; if they are combined pick and pick they form a 63° twill. If three regular 45° twills are combined by taking a pick of each in regular order they form a 72° twill; if they are combined by taking an end of each in regular order they form an 18° twill.

EXAMPLES FOR PRACTICE

1. Show one repeat of the regular $\frac{4}{4}\frac{3}{3}$ twill on design paper.

2. From the weave formed in answer to question 1 form a weave by arranging the ends in the following order: taking the first end, skipping 2, taking the next, skipping 2, and so on until the new weave repeats.

3. Take the two weaves given in answer to questions 1 and 2 and combine them pick and pick, taking the first pick of the weave given for question 1, then the first pick of the weave given for question 2, and so on.

4. If a 10×10 twill is combined pick and pick with a 6×6 twill, on how many ends and picks will the new weave be complete?

5. If a 16×16 weave is combined end and end with an 8×8 weave, how many ends and picks will the new weave occupy?

FANCY TWILLS

14. In addition to the regular 45° twills there are many other twill weaves that may be considered as subdivisions of regular twills; these are very useful in many classes of fabrics. The first of these weaves that will be considered are those known as **fancy twills.** These weaves generally consist of a regular twill weave between the twill lines of which are placed sometimes other twills running in the

opposite direction, sometimes small spots, and sometimes other small weaves.

The first step in making such weaves is to construct a bold line of twill running across the design, as shown in Fig. 33. In order to change this regular twill into a fancy twill, it is

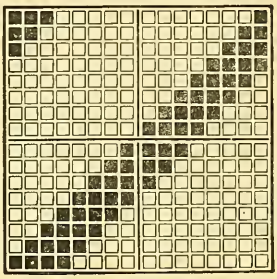


Fig. 33

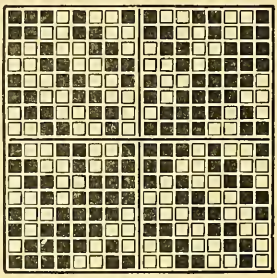


Fig. 34

necessary to insert some other weave on the blank squares. Fig. 34 shows this twill changed to a fancy twill; the method employed is that of running short lines of twill in a direction opposite to that of the main line of twill.

Figs. 35 and 36 show two other fancy twills. In Fig. 35, the fancy twill is formed by placing small spots between the

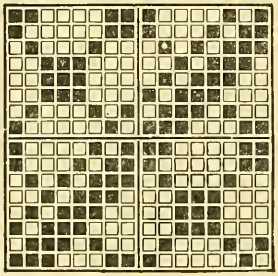


Fig. 35

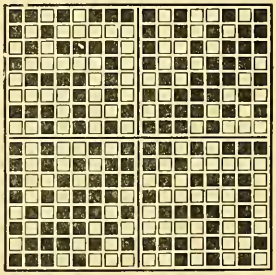


Fig. 36

main lines of twill; while in Fig. 36, the fancy twill is formed by placing a small weave, as shown, between the main lines of twill.

In making these weaves it should be noted that the entire weave runs up in a twill line and that it is essential to have

the first and last ends and also the first and last picks match; that is, the first end of the weave should be a continuation of the last end and the first pick should be a continuation of the last pick, so that the weave will continue perfectly when repeated in either direction. In order to accomplish this, it is necessary to have the spot or weave that is inserted occupy a number of picks that can be divided into the number of picks on which the entire weave is complete; otherwise, it will be necessary to continue the twill and spot weaves until a point is reached where they repeat together, which will occur on a number of picks equal to the least common multiple of the number of picks required by the twill and by the spot weave.

Fig. 37

In Fig. 34, the small twill weave may be said to occupy 4 picks, which is exactly divisible into 16, the number of picks that one repeat of the completed weave occupies. In Figs. 35 and 36, each inserted weave may be said to occupy 4 picks; this number is exactly divisible into 16, the number of picks that the complete weaves occupy.

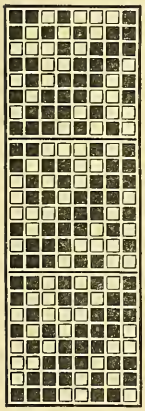


Fig. 38

When the weave that is inserted between the twill lines repeats on a different number of picks, the twill and inserted weave are both repeated in the picks until they repeat together, which occurs on a number of picks equal to the least common multiple of the number of picks on which the twill and spot weave are complete. For instance, suppose that it is desired to make a fancy twill weave by inserting Fig. 37 between the twill lines of a $\frac{3}{5}$ twill. Fig. 37 is complete on 6 picks, while the twill requires 8 picks; therefore, the completed fancy twill will require 24 picks, since 24 is the least common multiple of 6 and 8 and both will not commence to repeat together until the twenty-fifth pick. Fig. 38 shows the fancy twill thus obtained.

ENTWINING TWILLS

15. Entwining twills are constructed from regular twills by running sections of twill lines both to the right and to the left so that each section meets other sections at right angles. As their name indicates, the effects produced by these twills have an entwined or interlaced appearance; the more perfect ones are obtained when the separate sections are composed of equally flushed twills, although in some cases unequally flushed twills give good results. Fig. 39 shows an entwining twill constructed by running two twill lines of the cassimere to the right and two to the left, the weave repeating on 8 ends and 8 picks. Although two repeats in the ends and two in the picks are shown here, when constructing these twills, the number of ends and picks that one repeat of the weave will occupy must be ascertained at the start. This may be found by multiplying the number of ends and picks required for one repeat of the weave used by the number of twill lines in each section; thus, since in Fig. 39 two twill lines of the cassimere, or $\frac{2}{2}$, twill are used, the completed entwining twill occupies 8 ends and 8 picks ($2 \times 4 = 8$). If it is desired to construct an entwining twill with the cassimere twill and have three twill lines in each section, 12 ends and 12 picks ($3 \times 4 = 12$) will be required to show one repeat; if four twill lines in a section are wanted, 16 ends and 16 picks will be required, and so on. If the 6-end regular twill $\frac{3}{3}$ is used as a base instead of the cassimere and three twill lines are desired in each section, 18 ends and 18 picks ($3 \times 6 = 18$) will be required for one repeat of the completed entwining twill. In constructing an entwining twill, therefore, it is first necessary to decide on the twill weave to be used as a base and also on the number of twill lines to be used in each section, from which the number of ends and picks required for one repeat can be found.

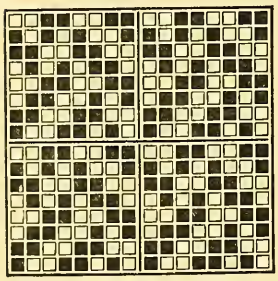


Fig. 39

To illustrate the method of constructing these weaves, suppose that it is desired to make an entwining twill with the cassimere twill $\frac{2}{2}$, having five twill lines in each section, which will give an entwining twill complete on 20 ends and 20 picks ($5 \times 4 = 20$). The first step is to run up the first twill line of one section, as shown in Fig. 40 (*a*), continuing

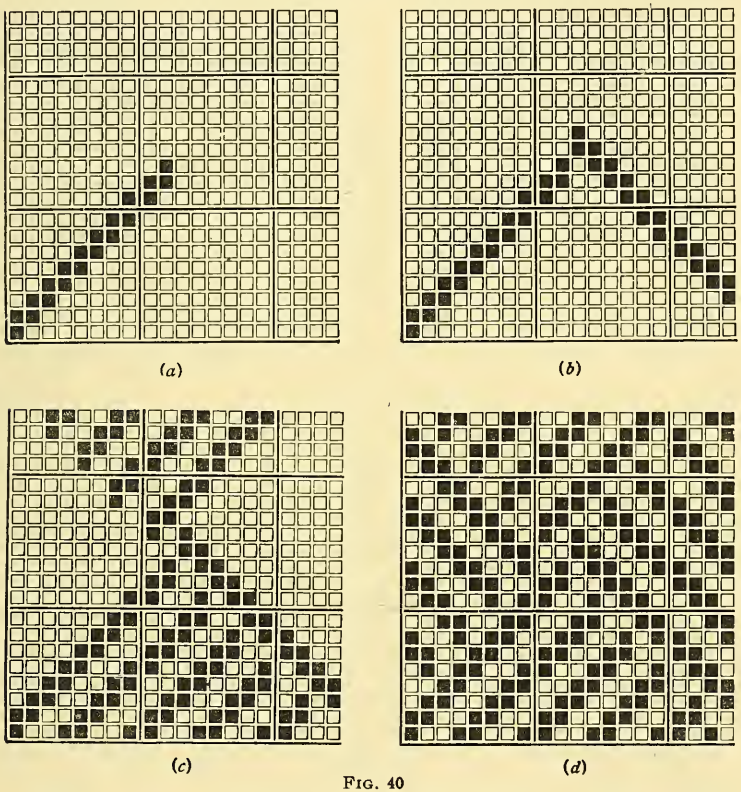
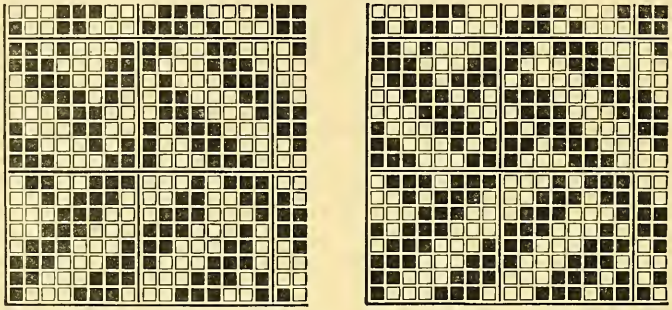


FIG. 40

it for a number of ends equal to one-half the total number of ends to be occupied by the repeat. Next insert the first twill line of the section of twill lines that run in the opposite direction, starting it on the next end to and just above the last riser of the first twill line and running it down in the opposite direction, as shown in Fig. 40 (*b*). Next return to the

first section, that is, the one running to the right, and complete it by running the four other twill lines parallel to the first twill line that has already been obtained. Each twill line must be continued, as shown in Fig. 40 (*c*), until it



(*a*) (*b*)

FIG. 41

occupies the same number of ends as the first twill line; namely, a number of ends equal to one-half of the number occupied by the completed weave, or in this case 10 ends. By completing the section of twill lines running to the left in the same manner, that is, by adding the other four twill lines parallel to the one already obtained, the completed weave is obtained, as shown in Fig. 40 (*d*).

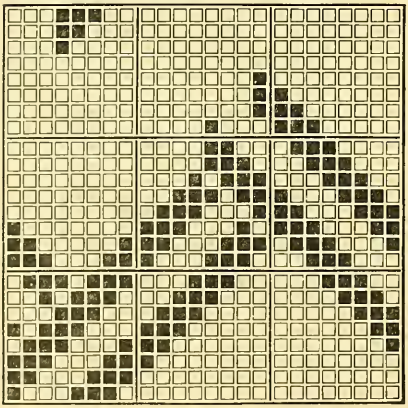


FIG. 42 (*a*)

When the warp floats over more than 2 picks in a twill used as the base of an entwining twill, it is usually advisable to add one or more extra risers to the ends of each warp twill line in order to make the twill lines meet each other better and also to shorten the warp floats on the back of the cloth at the junction of the right and left twill lines. For instance, Fig. 41 (*a*) shows an entwining

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twill constructed with three lines of the $\frac{3}{3}$ regular twill in each section, and while this weave is perfectly constructed, if one extra riser is added to each end of every twill line, as shown in Fig. 41 (*b*), the weave will be enhanced in value. It is very often necessary to alter the ends of each twill line, either by adding or taking out risers in order to make each twill line meet others in the best possible manner; especially is this true in the case of entwining twills based on unequally flushed weaves. As the repeat of the weave is already determined, the addition of extra risers will not alter the number of ends and picks in the repeat nor the number of harnesses necessary to weave the design.

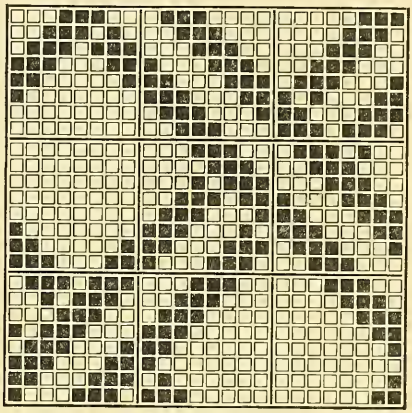


Fig. 42 (*b*)

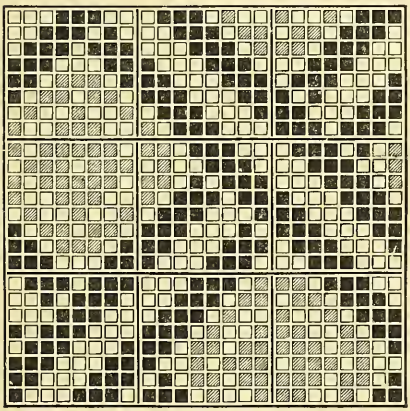


Fig. 42 (*c*)

Fancy entwining-twill effects are obtained by omitting one or more twill lines from each section and continuing the remaining twill lines of each section until they meet those of the other section. By this means two blank spaces are made in the weave, in which other weaves may be inserted. To illustrate the construction of these weaves, suppose that it is desired to make a fancy entwining-twill effect on 24 ends and 24 picks with the $\frac{3}{3}$ twill. In an ordinary entwining twill, this would

require four twill lines in each section, but since this is to be a fancy effect two of the twill lines in each section will be omitted. Fig. 42 (*a*) shows the weave constructed up to this point, but since two twill lines have been omitted from each section it is necessary to continue the two remaining twill lines across the space that would have been occupied by the other twill lines until they meet those of the other section, as shown in Fig. 42 (*b*). This leaves two blank spaces, as shown, in which any desired weave may be inserted, thus producing a fancy entwining twill, as shown in Fig. 42 (*c*), where the inserted weave is indicated by the shaded risers.

CURVED TWILLS

16. Curved twills are those in which the twill lines have a wavy, or curved, nature instead of being perfectly straight as in an ordinary twill weave. There are two methods of constructing these weaves, although the results are very similar in either case.

The first method consists of amalgamating several sections of twill weaves running at different angles, while by the second method the curved effect is obtained with a regular twill weave for a chain draft and a drawing-in draft so arranged as to produce the desired effect. Fig. 43 shows several repeats of a curved twill constructed in accordance with the first method. This weave repeats on 32 ends and 8 picks and is composed of four sections of 8 ends each; the first section is the regular 8-end 45° twill $\frac{4}{4}$; the second section is a twill having an angle of 63°; the third section is a twill with an angle of 72°; and the fourth section is like the second. It will be noticed that each end of the weave interlaces in the same manner as some one of the first 8 ends; therefore, the weave may be woven with 8 harnesses and the first 8 ends as a chain draft if the proper drawing-in draft is used; this shows that the second method of constructing curved twills is really based on the first.

Fig. 44 (*a*) shows several repeats of a curved twill constructed by the second method with the chain draft shown in

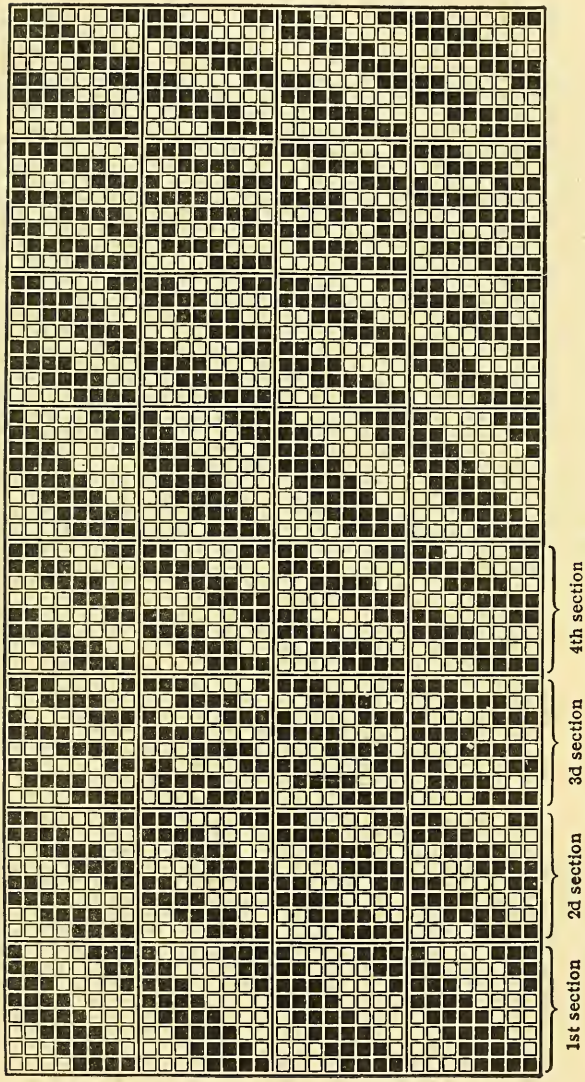
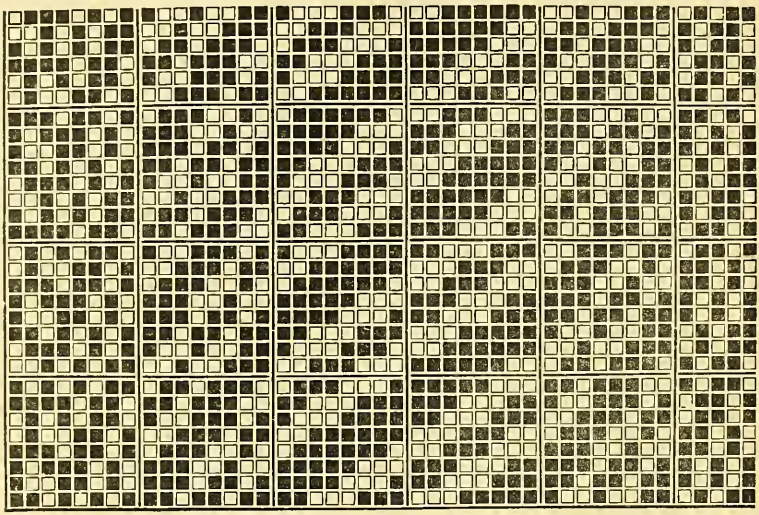
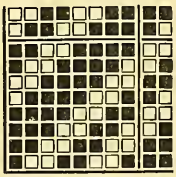


FIG. 43

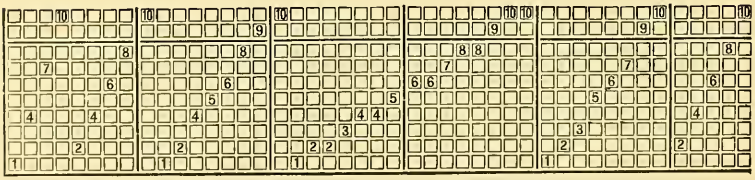
Fig. 44 (*b*) and the drawing-in draft Fig. 44 (*c*). The first end of the effect in Fig. 44 (*a*) is like the first end of Fig. 44 (*b*); the second end is like the fourth end; the third,



(*a*)



(*b*)



(*c*)

FIG. 44

like the seventh; the fourth, like the tenth; and so on, each end of Fig. 44 (*b*) being taken in the order indicated by the drawing-in draft in Fig. 44 (*c*).

SKIP TWILLS

17. **Skip twills** are a type of broken twill effects formed by a skip drawing-in draft and a regular twill weave as a chain draft. The drawing-in draft is made so that the ends are drawn in straight for a certain number of harnesses; a number of harnesses are then missed; and afterwards the ends are again drawn in straight. The draft is so constructed that when the harnesses are skipped, the end in the harness just before the skip will rise and fall exactly opposite to the next end; by this means a broken effect is formed in the cloth. In Fig. 45 (*a*) is shown a skip twill that is made with the 6-end regular twill $\frac{3}{3}$, Fig. 45 (*c*), as a chain draft and the skip drawing-in draft shown in Fig. 45 (*b*). In this draft the first 3 ends are drawn straight; then 2 harnesses are skipped; 3 more ends are then drawn straight, and so on until a repeat is found.

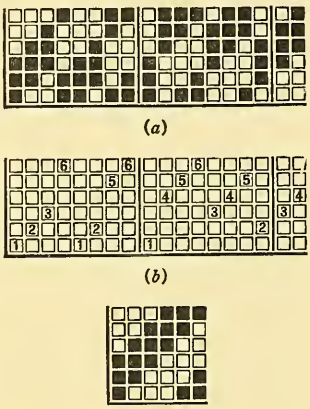
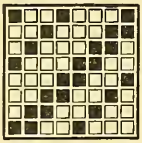


FIG. 45

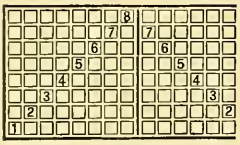
In this weave the fourth end rises and falls exactly opposite to the third end. This is accomplished by means of drawing the fourth end through the sixth harness instead of the fourth, as would be done with a straight draft. The seventh end rises and falls exactly opposite to the sixth, the tenth end opposes the ninth in the same manner, and so on until the eighteenth end is reached, which rises and falls exactly opposite to the first end. One end rising and falling in opposition to another in this manner is termed *cutting*. Skip twills are best constructed from equally flushed twills.

POINTED TWILLS

18. Another class of twill weaves obtained by means of the harness draft includes those weaves obtained by point drafts, which form wave effects across the cloth known as **pointed twills.** These effects are also frequently spoken of as *herring bones*, or *herring-bone stripes*, because the radiating twill lines suggest the radiating bones of a fish's backbone. Suppose that it is desired to make a pointed, or wave, effect with the 45° twill shown in Fig. 46 (*a*) as the chain draft; Fig. 46 (*b*) shows the harness draft that will be used, while Fig. 46 (*c*) shows the effect obtained in the cloth.



(*a*)



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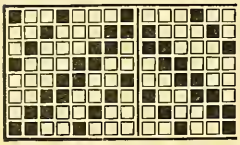
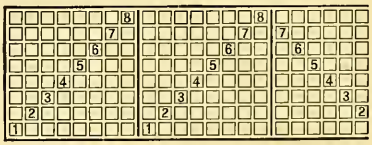


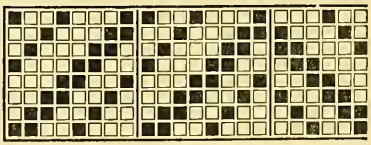
(*c*)

FIG. 46

One important point in connection with point drafts is that they always end on the second harness and not on the first, that is, assuming that the draft begins on the first harness. For instance, in Fig. 46 (*b*), the ends are drawn straight for the first 8 harnesses, when they are reversed, commencing with the seventh harness; when the harness draft reaches the second harness after being reversed, one repeat of the draft is obtained. If the last end of the draft were drawn through the first harness, the first and last ends of each repeat would work exactly alike, which would give in the cloth 2 ends side by side working alike. This would cause a serious defect in the fabric. If the weave shown in Fig. 46 (*c*) is repeated two or



(*a*)

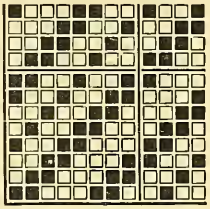


(*b*)

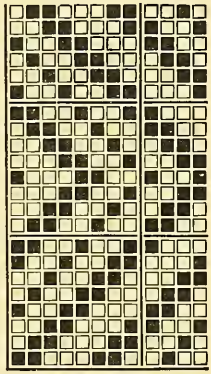
FIG. 47

three times in both ends and picks, a better idea of the waves formed by these weaves will be obtained.

Many good effects can be obtained by this method by changing the harness draft and using the same chain draft. Thus, instead of using a regular point draft like that shown in Fig. 46 (*b*), a draft like that shown in Fig. 47 (*a*) may be used; the effect, or weave, in this case, will be similar to that shown in Fig. 47 (*b*).



(*a*)



(*b*)

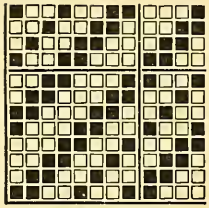
FIG. 48

19. The point twills thus far described will make waves across, or widthwise of, the cloth. The same effects, however, may be made to extend lengthwise of the cloth by simply reversing the chain draft in the same manner that the harness draft was reversed when making waves across the cloth.

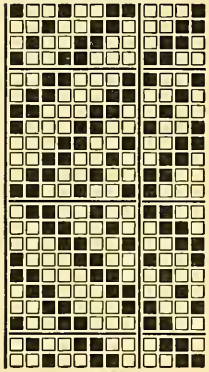
Suppose that it is desired to make a chain draft that will give a wave running lengthwise of the cloth from the twill shown in Fig. 48 (*a*). It is simply necessary to make a chain draft that will have the first 12 picks similar to Fig. 48 (*a*) and the remaining picks made by reversing these first 12 picks; that is, the thirteenth pick will be like the eleventh; the fourteenth, like the tenth; the fifteenth, like the ninth; the sixteenth, like the eighth; the seventeenth, like the seventh; the eighteenth, like the sixth; the nineteenth, like the fifth; the twentieth, like the fourth; the twenty-first, like the third; and the twenty-second, like the second. Here the chain draft will stop, in order to avoid having the first and last picks alike, on the same principle that the harness drafts of weaves making waves across the cloth stop on the second harness. Fig. 48 (*b*) shows the chain draft to give the wave lengthwise of the cloth; the harness draft will be a 12-harness straight draft.

DIAMOND WEAVES

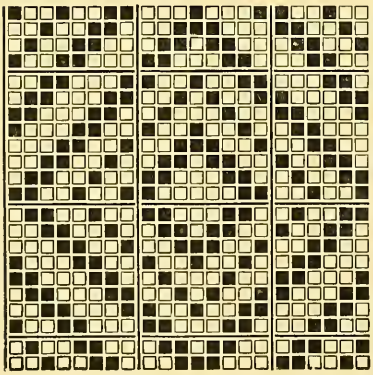
20. By reversing both the harness and chain drafts of any regular twill, another class of weaves that is very largely used, and known as **diamond weaves** from the effects formed in the cloth, will result.



(*a*)



(*b*)



(*c*)

FIG. 49

Fig. 49 (*a*) shows a regular twill from which it is desired to construct a diamond weave. First build the chain draft by reversing the picks exactly as when forming waves lengthwise of the cloth. For the purpose of illustration, however, the picks will be reversed from the first pick, instead of from the last as in the previous illustration. It should be understood that in either case the weave will be the same. Fig. 49 (*b*) shows Fig. 49 (*a*) reversed in this manner. Fig. 49 (*b*) should be considered as the chain draft of the desired weave, while the drawing-in draft will be a regular point draft made on the same principle as the drawing-in drafts for the regular weaves that were made into waves extending across the cloth. The chain draft occupies 12 harnesses and consequently the drawing-in draft will be the 12-harness regular point draft. In other words, the ends will be drawn in the following order: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2. It should be noticed that in this case, as well as in weaves forming wave effects, the last

pick joins perfectly with the first; also the last end with the first. In order to show the effect that will be formed in the cloth when using Fig. 49 (*b*) for the chain draft and drawing in the warp ends as described, the weave has been worked out and is shown in Fig. 49 (*c*).

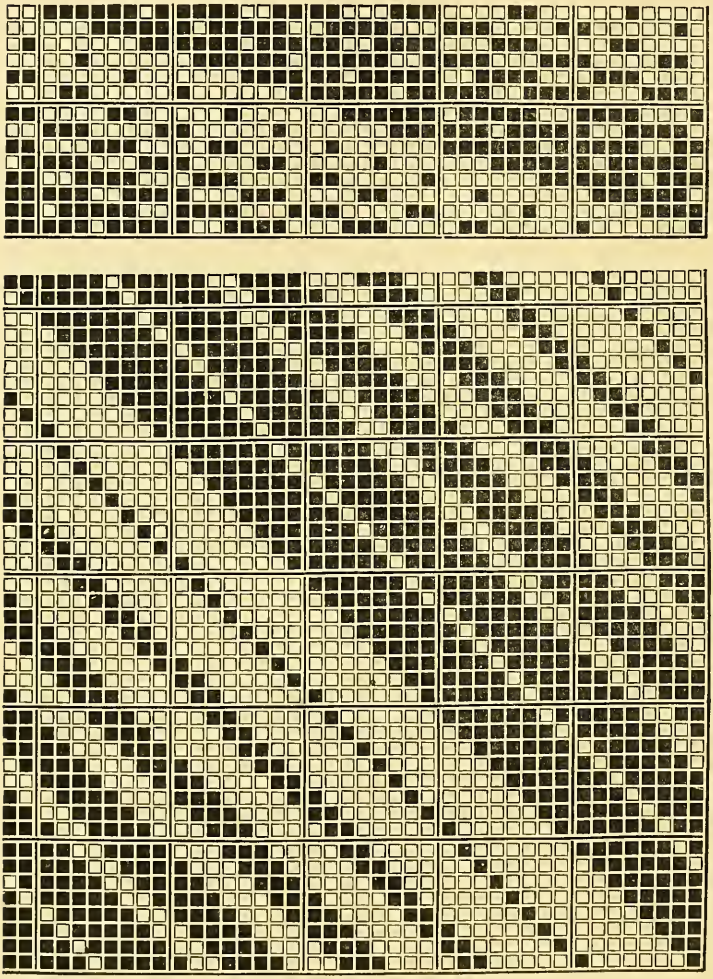
DIAGONAL WEAVES

21. Shaded Diagonals.—Diagonal weaves may be considered as a type of twill weaves, the term being generally confined to bold twills running at angles greater than 45°, although often regular 45° twills are spoken of as diagonals; regular diagonals are generally formed by combining two regular 45° twills in their picks or ends. As the formation of other weaves by combining twills pick and pick or end and end has been fully explained, it will not be necessary to give further details of these weaves, but simply to state that all the examples under this method of forming weaves may be considered as diagonals.

There is, however, a subdivision known as **shaded diagonals,** which are formed on a twill basis by taking as the base of the twill a different number of risers and sinkers in the different sections, grading from light to dark or from dark to light. For instance, suppose that a shaded diagonal is to be made from a regular 45° twill that is complete on 42 ends and 42 picks. Divide the first pick of the weave into six sections of 7 ends each. Then beginning with the first section leave only 1 end down; that is, this part would be marked $\frac{6}{1}$. In the next section leave 2 ends down, making this section $\frac{5}{2}$. Continuing in this manner, the next section will be $\frac{4}{3}$; the next section, $\frac{3}{4}$; the next section, $\frac{2}{5}$; while the last section will be marked $\frac{1}{6}$; therefore, the first pick of this weave would be marked $\frac{6}{1}\,\frac{5}{2}\,\frac{4}{3}\,\frac{3}{4}\,\frac{2}{5}\,\frac{1}{6}$. It is next necessary to run up this twill in the regular 45° manner until it is complete; that is, until it occupies 42 ends and 42 picks. Fig. 50 (*a*) shows the complete weave.

After the regular twill has been formed it is necessary to decide what angle the diagonal shall form. If it is to be

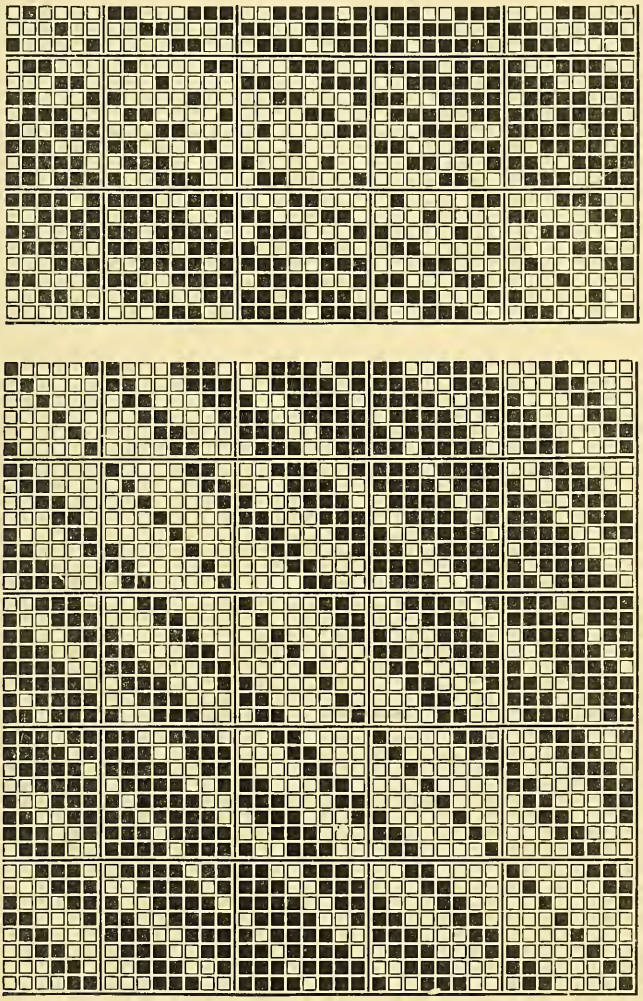
a 63° diagonal, every other end of the regular twill may be taken. If it is to form an angle of 72°, every third end of the regular twill will be taken, and so on. Suppose that in



(a) (b) FIG. 50

this case it is desired to have the diagonal form an angle of 72°. Then every third end of the regular twill shown in Fig. 50 (*a*) will be taken. As 3 can divide evenly into 42,

the number of ends on which Fig. 50 (*a*) is complete, the diagonal is complete on 42 ÷ 3, or 14, ends. Commencing then with the first end in Fig. 50 (*a*) and taking every third



(*b*)

(*a*)

FIG. 51

end of the weave, Fig. 50 (*b*) will result. Thus, the first end of Fig. 50 (*b*) is the first end of Fig. 50 (*a*); the second end of Fig. 50 (*b*) is the fourth end of Fig. 50 (*a*); the third

end of Fig. 50 (*b*) is the seventh end of Fig. 50 (*a*); and so on until every third end of the regular twill has been taken. Fig. 50 (*b*) will form a shaded effect in the cloth; that is, commencing with a certain part of the weave a large part of the warp will be found to float on the surface. The weave is then shaded gradually until a point is reached where the filling will be found to predominate largely on the surface.

In many cases these diagonals are made to shade in both directions; that is, the warp floats will be found gradually to grow less until the filling predominates, when the weave will again be shaded until the warp predominates, instead of breaking off suddenly as in Fig. 50 (*b*).

In making the regular twill weave for the base of a shaded diagonal, the most perfect results are obtained if the weave is equally flushed. In order to find this base, the following method is employed: Mark the numbers that indicate the number of warp ends to be lifted over the first pick, beginning with 1 and running up as high as desired, repeating the highest number and then grading down again but stopping with 2 instead of 1; thus, $\underline{1\ 2\ 3\ 4\ 4\ 3\ 2}$. Then put 1 to represent one end down between the two highest numbers and grade in each direction until the highest number is reached at each end; thus, $\underline{1\ 2\ 3\ 4\ 4\ 3\ 2}$ / $4\ 3\ 2\ 1\ 2\ 3\ 4$. This method makes a perfect, equally flushed weave, since the same number of warp ends are up as are down, and also where 4 warp ends are up in succession 1 end is down between them, and where 4 warp ends are down in succession 1 warp end is up between them. Fig. 51 (*a*) shows the regular twill weave formed in this manner with the base given, and Fig. 51 (*b*) shows a 63° diagonal derived by taking every other end in proper rotation.

Shaded diagonal weaves are woven with a warp of one solid color and a filling of another solid color opposed to that of the warp, as for instance, a black warp and white filling, or vice versa; this brings out the shaded effect of the weave.

EXAMPLES FOR PRACTICE

1. Make a regular twill weave from the base $\frac{1}{5}\frac{2}{4}\frac{3}{3}\frac{4}{2}\frac{5}{1}$.

2. From the weave given in answer to question 1 construct a 72° shaded diagonal.

3. Extend the base of the twill given in question 1 and from the twill formed by this new base construct a 63° shaded diagonal that will be shaded in both directions.

4. Make an original diamond weave.

SATIN AND OTHER WEAVES

Serial 507 — Edition 1

SATINS

1. **Satin, or sateen,** weaves constitute one of the most valuable classes of fundamental weaves, and are used in almost every branch of weaving and with yarns of every material. They are used in woolen cloths to produce *doeskins*, in cotton cloths for the production of *sateens* and *satinettes*, and in silk goods for *satins*. One of the largest uses of satin weaves is in the production of linen damasks, in which warp-flush and filling-flush satins are combined to produce figured table cloths, napkins, etc. They are also largely used as ground weaves for spotted and figured cloths and are often combined to form check and stripe effects in various fabrics.

2. **Comparison of Twills and Satins.**—Satin weaves, in a certain sense, are the exact opposite of twills, since while it is the object of a twill weave to show a twill line running diagonally across the cloth, in the satin weave all twill lines are avoided as far as possible, although in some cases a slight twill effect is shown in a cloth woven with a satin weave, by means of the direction of the twist in the warp and filling yarns. Another of the principal features of a twill weave is the supporting of one end by another, but in a satin weave this is carefully avoided; that is, in a satin weave the interlacing of each end is at least 1 pick apart from the interlacing of either of the ends next to it. In a regular satin weave, each end interlaces with the filling only

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once in one repeat of the weave. Fig. 1, which shows a 5-end warp-flush twill, and Fig. 2, which shows a 5-end warp-flush satin, illustrate these points. Although in the twill weave only one interlacing is made on each pick, the ends support each other, since on the first pick the first end is down and on each succeeding pick the next end is down, thus forming a twill line. With the satin weave, only 1 end is down on each pick, it being in this respect similar to the twill weave, but the interlacing of each end is at least 1 pick apart from the interlacing of either of the 2 ends next to it. Thus on the first pick, the first end is down; on the next pick, the fourth end is down; on the third pick, the second end is down; on the fourth pick, the fifth end is down; and on the fifth pick, the third end is down; consequently, the points of interlacing do not run up in regular order, as is the case in a regular twill weave, but are scattered over the weave. By this means the interlacings of the warp and filling are almost entirely hidden, while the cloth produced is smooth and soft, this being the object of the weave.

Fig. 1

Fig. 2

3. Base for Satin Weaves.—The order in which the ends are raised or lowered when forming a satin weave is generally indicated by a series of figures, in which each figure represents an end, while its position in the series indicates the pick on which it is moved. Thus, referring to the 5-end satin in Fig. 2, the ends would be said to be lowered in 1, 4, 2, 5, 3 order: 1 being the first number, shows that the first end is lowered on the first pick; 4 being the second number, shows that the fourth end is lowered on the second pick; 2 being the third number, shows that the second end is lowered on the third pick; 5 being the fourth number, shows that the fifth end is lowered on the fourth pick; and 3 being the fifth number, shows that the third end is lowered on the fifth pick.

Considering the order of moving the ends, as shown in Fig. 2, on each successive pick, the third end (counting

from left to right) from the one previously lowered is down. Thus, on the first pick, the first end is down; on the second pick, the third end from that, or the fourth, is down; on the next pick, the third end from the fourth, or the second, is down; and so on for the 5 picks that complete one repeat of the weave. This is known as *moving in threes;* that is, 3 is taken as a base for constructing the weave. When determining the base on which to construct a satin weave, any number may be taken that is neither a factor of the whole number of ends in one repeat nor a multiple of any such factor, exclusive of the number 1 and the number that is 1 less than the number of ends on which the satin under consideration is complete. Thus, in the case of the 5-end satin, 3 is a number that cannot be equally divided into 5, the number of ends in the repeat; neither can any number that is equally divisible into 5 be equally divided into 3. The number 2 could also be taken as the base for a 5-end satin, in which case the ends would be moved in the following order: 1, 3, 5, 2, 4.

4. Warp- and Filling-Flush Satins.—Satin weaves may be either **warp-flush** or **filling-flush;** the former contains more warp yarn on the face, while the latter contains more filling on the face. Warp and filling satins, as shown on design paper, may be readily distinguished, for if there are more filled-in than blank squares, as in Fig. 2, the warp will predominate, since filled-in squares represent the warp ends lifted, and the weave will be a *warp satin.* In case there are more blank than filled-in squares, as in Fig. 3, the weave will be a *filling satin,* since the blanks represent filling over warp.

Fig. 3

When a satin is a warp satin, the ends are said to be *lowered* in a certain order, while with a filling satin the ends are said to be *raised* in a certain order. Thus, for example, in speaking of the weave in Fig. 2, the ends are said to be lowered in 1, 4, 2, 5, 3 order, while the ends of the filling satin shown in Fig. 3 are said to be lifted in 1, 4, 2, 5, 3 order.

Cloths with a satin weave are sometimes woven face down, in which case a warp satin has the ends *raised* according to the base of the satin, while a filling satin has the ends *lowered* according to the base. In this Course, however, cloth will always be considered as woven face up unless a definite statement to the contrary is made.

A filling satin generally contains more picks per inch than ends, so that the ends that are raised over the picks are nearly covered, thus causing the cloth to have a very soft feeling. A similar effect is produced in a warp satin, which generally contains more warp ends per inch than picks, thus causing the warp ends to crowd over the picks that are raised.

5. Six-End Satin.—The smallest number of ends on which a regular satin can be constructed is 5. It cannot be constructed on 6 ends, although in many cases a weave known as an *irregular satin* is made on 6 ends, the order of moving the harnesses being either 1, 3, 5, 2, 6, 4 or 1, 4, 2, 6, 3, 5. With weaves in which the ends are raised or lowered in either of these orders, no two adjacent ends are moved on successive picks; or in other words, no two ends support each other, and yet the same number of ends are not skipped between successive picks. Take, for example, the first order. If a warp satin is being considered, on the first pick the first end is lowered; on the second pick the second end from the one previously lowered, counting from left to right, or the third, is lowered; on the the third pick the second end from the previous one, or the fifth, is lowered; but on the next pick the third end from the fifth, or the second, is lowered; on the next pick the fourth end from the second, or the sixth, is lowered; while on the last the fourth end from the sixth, or the fourth, is lowered. Thus, in certain parts of the weave the base for counting off the ends is 2; in others it is 3; while in still others it is 4.

6. Construction of Satin Weaves.—To illustrate more fully the method of obtaining the base for any satin weave, it will be supposed that it is desired to make a regular satin on 7 ends. In any case where it is desired to construct

a satin weave on an odd number of ends, 2 can always be taken as the base, since 2 is neither a factor of any odd number nor a multiple of any factor of an odd number. Thus, in a 7-end satin the ends can be moved in 1, 3, 5, 7, 2, 4, 6 order, in which case the order of moving the ends is regular, and at the same time no two ends support each other; consequently, the satin will be regular. Another order of moving the ends in a 7-end satin is by threes, in which case the following results: 1, 4, 7, 3, 6, 2, 5; that is, on the first pick the first end is moved; on the second pick, the fourth end; on the third pick, the seventh end; on the fourth pick, the third end; on the fifth pick, the sixth end; on the sixth pick, the second end; and on the seventh pick, the fifth end. Still another base that may be taken for a 7-end satin is 5, in which case the ends are moved in the following order: 1, 6, 4, 2, 7, 5, 3. Another base is 4, in which case the ends are moved as follows: 1, 5, 2, 6, 3, 7, 4.

For another example, suppose that it is desired to construct a satin weave on 9 ends. It is first necessary to obtain a number smaller than 9 that is not equally divisible into the total number of ends and that cannot be divided equally by any number that can be divided into 9. The number 5 answers these conditions, and if taken as a base for moving the ends will give the following: 1, 6, 2, 7, 3, 8, 4, 9, 5. With this order, the first end is moved on the first pick; on the second pick, the sixth end is moved; on the third pick, the second; on the fourth pick, the seventh; and so on until all the ends are moved once, which gives one repeat of the weave.

Fig. 4

Fig. 4 shows a 7-end filling satin constructed on a base of 3. On the first pick, the first end is raised; on the second pick, 2 ends are missed and the fourth end raised; on the next pick, 2 ends again are missed and the seventh end raised. This method of skipping is continued for 7 picks, which is one repeat of the weave. When the last end, or in this case the seventh, is reached, the next end to be counted is the first. Thus, for instance, on the third pick of this weave the seventh end

is raised. Counting from this end to see which end will be raised on the next, or fourth, pick, the first end is considered as 1, the second as 2, and the third end from the seventh will be the third end of the weave, which will be the end to be raised on this pick. This is due to the fact that as one repeat of the weave occupies only 7 ends, the eighth end of the weave is like the first, the ninth like the second, and so on.

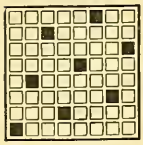


Fig. 5

Fig. 5 shows an 8-end filling satin constructed on a base of 3; that is, one end is raised on one pick and on the next pick the third end from the one previously raised is lifted.

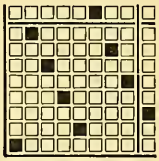


Fig. 6

Fig. 6 shows a 9-end filling satin weave constructed on a base of 4. Thus, on the first pick, the first end is raised; on the second pick, the fourth end from this one, or the fifth, is raised; on the third pick, the fourth end from the fifth, or the ninth, is raised; on the fourth pick, the fourth end from the ninth, or the fourth, is raised. This is continued for the 9 picks, which completes the repeat.

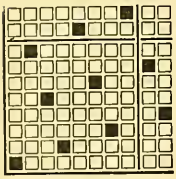


Fig. 7

Fig. 7 shows a 10-end filling satin with a base of 3.

Fig. 8 shows a 9-end warp satin weave constructed on a base of 4. In warp satins all the ends in one repeat of the weave are up on each pick with the exception of one pick. Thus, in the case of Fig. 8, on the first pick all the ends are raised with the exception of the first end; on the second pick, the fourth end from this first end, or the fifth, is lowered; on the third pick, 3 ends are skipped and the ninth end is lowered; on the fourth pick, 3 ends are skipped and the fourth end is lowered. This is continued for the 9 picks that complete one repeat of the weave.

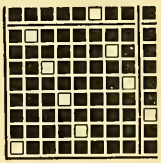


Fig. 8

Fig. 9 shows a 10-end warp satin weave constructed on a base of 3.

7. The lifting of the harnesses in a filling satin weave is given in the order that the ends are raised on each successive pick. Thus, for instance, in Fig. 5 the harnesses are raised in 1, 4, 7, 2, 5, 8, 3, 6 order. This indicates that on the first pick, the first harness is raised; on the second pick, the fourth harness is raised; on the third pick, the seventh harness is raised; on the fourth pick, the second harness is raised; on the fifth pick, the fifth harness is raised; on the sixth pick, the eighth harness is raised; on the seventh pick, the third harness is raised; on the eighth pick, the sixth harness is raised.

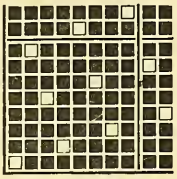


Fig. 9

5-End Satins

1, 4, 2, 5, 3
1, 3, 5, 2, 4

6-End Satins

1, 3, 5, 2, 6, 4
1, 4, 2, 6, 3, 5

7-End Satins

1, 4, 7, 3, 6, 2, 5
1, 3, 5, 7, 2, 4, 6
1, 6, 4, 2, 7, 5, 3
1, 5, 2, 6, 3, 7, 4

8-End Satins

1, 4, 7, 2, 5, 8, 3, 6
1, 6, 3, 8, 5, 2, 7, 4

9-End Satins

1, 3, 5, 7, 9, 2, 4, 6, 8
1, 8, 6, 4, 2, 9, 7, 5, 3
1, 5, 9, 4, 8, 3, 7, 2, 6
1, 6, 2, 7, 3, 8, 4, 9, 5

10-End Satins

1, 4, 7, 10, 3, 6, 9, 2, 5, 8
1, 8, 5, 2, 9, 6, 3, 10, 7, 4

11-End Satins

1, 3, 5, 7, 9, 11, 2, 4, 6, 8, 10
1, 10, 8, 6, 4, 2, 11, 9, 7, 5, 3
1, 4, 7, 10, 2, 5, 8, 11, 3, 6, 9
1, 9, 6, 3, 11, 8, 5, 2, 10, 7, 4
1, 5, 9, 2, 6, 10, 3, 7, 11, 4, 8
1, 8, 4, 11, 7, 3, 10, 6, 2, 9, 5
1, 6, 11, 5, 10, 4, 9, 3, 8, 2, 7
1, 7, 2, 8, 3, 9, 4, 10, 5, 11, 6

12-End Satins

1, 6, 11, 4, 9, 2, 7, 12, 5, 10, 3, 8
1, 8, 3, 10, 5, 12, 7, 2, 9, 4, 11, 6

Generally a chain draft for a satin weave is made like the weave; that is, in most cases the weave is also the chain draft, and when this is the case the ends are drawn in straight, or in other words, through the harnesses in consecutive order.

450

The preceding table gives the different orders of moving the ends in satin weaves complete on 12 ends or less.

8. **Double Satins.**—Weaves known as **double satins** are sometimes constructed from regular satins. These are made by adding one mark to each mark in a regular satin; that is, in case the satin is a filling satin, each end will be raised an extra time during one repeat of the weave, and in case the satin is a warp satin, each end will be lowered an extra time during one repeat of the weave. These marks may be placed above, below, or at the side of the regular satin marks. Double satin weaves are principally used when it is desired to increase the strength of the goods and yet retain the satin face.

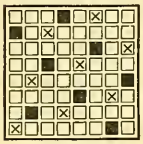


Fig. 10

Fig. 10 illustrates a double satin. The crosses represent a regular 8-end satin weave constructed on a base of 3, giving the following order of lifting the harnesses: 1, 4, 7, 2, 5, 8, 3, 6. In order to convert this regular satin weave into a double satin, one riser is placed on each pick in addition to the riser of the regular satin weave. Thus, on the first pick, in addition to the first end being raised the seventh end is also raised. In all double satin weaves the extra risers must be placed in regular order; that is, on the second pick the extra riser must be placed in the same relative position to the riser of the regular satin on that pick as was the extra riser on the first pick to the riser of the regular satin weave on that pick. Thus, on the first pick of the weave shown in Fig. 10, 5 ends are skipped after marking the riser for the regular satin, and the seventh end marked with an extra riser; on the second pick the fourth end is marked with a riser of the regular satin, 5 ends skipped, and the second end raised, which corresponds to the method of marking the extra riser on the first pick of the weave. This is continued throughout the 8 picks that complete one repeat of the weave.

Fig. 11 is another illustration of a double satin weave. In this case the extra risers are placed at the right of the risers

of the regular satin weave. Thus, on the first pick the first end is raised for the regular satin weave, and in order to make a double satin the square to the right of the one containing the riser of the regular satin weave is marked, or in other words the second end is raised with the first. The same method is followed with each pick of the weave.

Fig. 11

Fig. 12 shows an 8-end double satin. The crosses show the order of lifting the ends for a regular satin weave, while the filled-in squares show the extra ends that are raised in order to make the satin double.

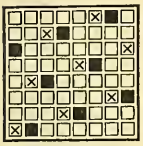


Fig. 12

Double satins are sometimes constructed by dividing the base that would be used for a regular satin into two numbers and using these numbers alternately for marking the risers of the double satin. Fig. 13, which is a 12-harness double satin constructed on this principle, illustrates these weaves. In this case the number 7, which could be used for the base of a regular satin on 12 ends, is divided into the two numbers 3 and 4 and these numbers used for constructing the weave. Considering first the squares that are marked with crosses, on the second pick, the fourth end from the end raised on the first pick is raised; on the third pick, the third end from the end raised on the second pick is raised; on the fourth pick, the fourth end from the end raised on the third pick is raised; on the fifth pick, the third end from the end raised on the fourth pick is raised. This is continued for the 12 picks, when it is necessary to return to the first pick; since on the twelfth pick the fourth end from the end raised on the eleventh pick is raised, on the first pick the third end from the end raised on the twelfth pick is raised. The filled-in squares show the risers that are obtained by continuing the process through the ends and picks the second time.

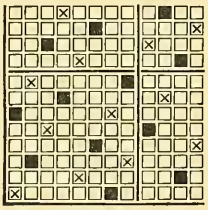


Fig. 13

Fig. 14 shows a weave made on somewhat the same principle as Fig. 13. In this case, however, the two risers are

marked on 1 pick before moving to the next pick. Thus, on the first pick the first end is raised and also the third end from the first. Moving to the second pick, the fourth end from the last end raised on the first pick is raised, which gives a riser on the eighth end for the second pick. In addition to this end being raised on the second pick, the third end from it is also raised, which gives a riser on the eleventh end. Moving to the third pick, as the eleventh end was the last end to be marked on the second pick, the third end, which is the fourth end from the eleventh, will be raised on the third pick. In addition to this end the third end from it, or the sixth, is also raised on the same pick. This method is continued throughout the 12 picks.

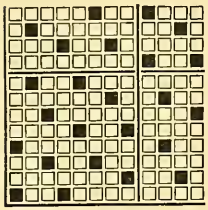


Fig. 14

EXAMPLES FOR PRACTICE

1. Make a warp satin on 16 harnesses, moving in fives.

2. Make a filling satin on 16 harnesses, moving in sevens.

3. From the weave formed in answer to question 2 construct a double satin by adding one riser on each pick of the satin weave.

4. (*a*) What is the smallest number of harnesses on which a regular satin weave can be constructed? (*b*) Show a satin weave on this number of harnesses.

DERIVATIVE WEAVES

9. Satin Derivatives.—Satin weaves provide a ready means for constructing other weaves, or **derivatives,** as they are called. In almost every case satin derivatives are formed by adding one or more extra risers to the risers of a regular satin. Fig. 15 shows one that might be considered

FIG. 15

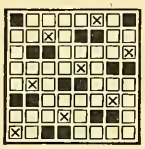


FIG. 16

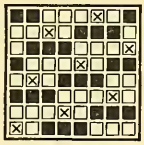


FIG. 17

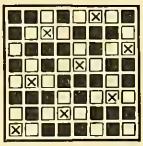


FIG. 18

a double satin, and yet would form a fine, upright twill in the weave. In the figures illustrating satin derivatives, the crosses show the method of raising the ends for the regular satin, while the filled-in squares show the risers that are added in order to form the derivatives. Fig. 16 is a satin derivative formed by adding two filled-in squares to each riser in a regular 8-end filling satin weave. Fig. 17 is one formed

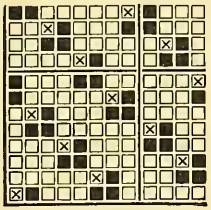


FIG. 19

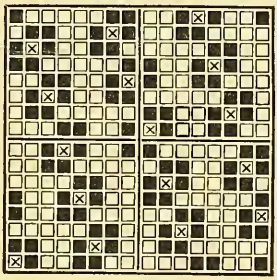


FIG. 20

by adding three risers to each riser in a regular 8-end satin. Fig. 18 is one formed by adding four risers to each riser of a regular 8-end satin weave. In all these cases, whenever it is necessary to extend the risers beyond the last end of the

weave they are carried to the first end, and in case it is necessary to extend the risers beyond the bottom pick of the weave they are carried to the top pick, or vice versa. Fig. 19 shows a derivative weave formed by adding three risers to each riser of a regular 12-end filling satin. Fig. 20 shows a satin derivative formed by adding six risers to each riser of a regular 16-end filling satin.

GRANITE WEAVES

10. In a **granite weave,** the intersections of the warp and filling are disposed throughout the weave in an irregular manner so that the floats of warp and filling will produce an indistinct yet regular pattern consisting of small broken effects. Granite weaves are largely used in almost every class of fabric, the cloths often being piece-dyed, but sometimes having the warp of one color and the filling of a contrasting color, thus giving the cloth a speckled appearance. They are made largely from regular satins by adding one or more risers to the risers of the satin weave; Figs. 16, 17, and 18 are good examples of granite weaves constructed in this manner. These weaves may also be obtained by rearranging a regular twill in so-called satin order; that is, taking the ends of the twill in the order followed when making a satin weave. For example, if the ends of an 8-end regular twill are rearranged in satin order on a base of 3, the ends are taken as follows: 1, 4, 7, 2, 5, 8, 3, 6; that is, the first end of the new weave will be like the first end of the twill; the second end will be like the fourth end of the twill; the third end will be like the seventh; the fourth end, like the second; the fifth end, like the fifth; the sixth end, like the eighth; the seventh end, like the third; and the eighth end, like the sixth. In other cases, granite weaves are constructed from regular twills by taking a certain number

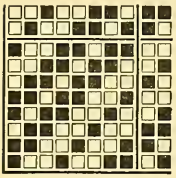


Fig. 21

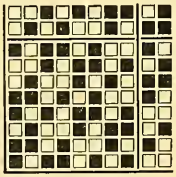


Fig. 22

of ends of the twill and then skipping a certain number, this being continued until the weave repeats. In the granite weave shown in Fig. 22, the ends of the regular twill shown in Fig. 21 have been rearranged by taking 2, skipping 4, and so on until the weave repeats.

BASKET WEAVES

11. Regular Basket Weaves.—Basket weaves are used frequently in all classes of woven fabrics; their chief feature is the regular occurrence of large floats of both warp and filling. The first type of basket weaves consists of those in which the squares of warp and filling are of equal size. These baskets are simply extensions of the plain weave both warp way and filling way, and it is always possible to weave them on 2 harnesses. Fig. 23 is a basket weave of this type, in which each square marked in a regular plain weave has simply been extended for 2 ends and 2 picks, thus making each mark occupy four squares instead of one. Fig. 24 shows another basket weave of this type, in which each mark of the plain weave has been extended for 3 ends and 3 picks; thus, instead of occupying only one square, each mark occupies nine. In Fig. 25, each mark is extended for 4 ends and 4 picks, and consequently occupies sixteen squares instead of one.

Fig. 23

Fig. 24

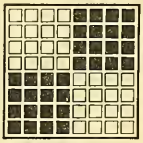


Fig. 25

12. Twill Baskets.—A second type of basket weaves consists of **twill baskets,** which are generally constructed on a satin base and produce much neater effects than the basket weaves just described. In making these weaves from a satin base, first mark out a satin weave on the desired number of ends and picks; then fill in squares around each of those marked off for the satin base, in such a manner that these groups of filled-in squares will form squares that run up in twill order. Fig. 26 shows a twill basket weave

constructed in this manner from an 8-end satin weave with a base of 5. The crosses show the satin weave, while the filled-in squares show the risers that are added in order to obtain the basket weave. In making these weaves, care should always be taken to have the filled-in squares around each mark of the satin base correspond in every particular;

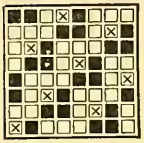


Fig. 26

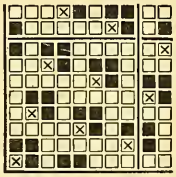


Fig. 27

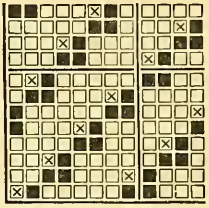


Fig. 28

that is, if on the first mark of the satin weave one square to the right and two below are filled in, as in Fig. 26, in the case of every other mark of the satin weave the corresponding squares must be filled in. Fig. 27 shows a twill basket weave constructed from a 10-end satin with a base of 7. Fig. 28 shows another one constructed from a 12-end satin with a base of 7.

13. Irregular Baskets.—A third type of basket weaves consists of **irregular baskets;** in these the squares of warp and filling are not exactly equal. Thus, in Fig. 29, the filled-in squares in one portion of the weave occupy 3 ends and 3 picks, while in another portion they occupy but 2 ends and 2 picks. In Fig. 30, the weave is formed by extending the warp floats in one case for 3 ends and 3 picks and in the other for 4 ends and 4 picks.

Fig. 29

Fig. 30

Fig. 31

14. Fancy Basket Weaves.—A fourth type of baskets consists of **fancy basket weaves.** In Fig. 31, the squares of filling are broken in the center by a float of warp, while the squares of warp are broken by a float of filling. Fig. 32

is another fancy basket weave constructed in the same manner. Fig. 33 shows a fancy basket weave constructed by separating warp floats of 4 ends and 4 picks each by 3 ends and 3 picks and filling in these intervening ends and picks with a suitable

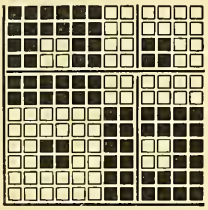


FIG. 32

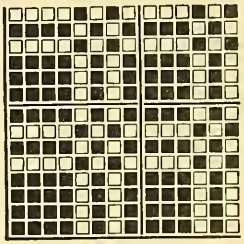


FIG. 33

weave. Two repeats of this weave in both ends and picks are shown in this figure. Fig. 34 is another weave made in somewhat the same manner. In this case, a plain basket weave consisting of warp and filling floats of 4 ends and 4 picks has the floats separated by 2 ends and 2 picks, which are filled in with a suitable weave. Two repeats of the weave in both ends and picks are given.

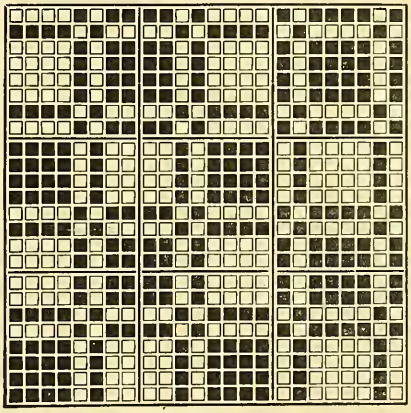


FIG. 34

RIB WEAVES

15. Warp Ribs. **Rib, or cord, weaves** are simply extensions of the plain weave in either the ends or picks alone and are of two classes—*warp ribs* and *filling ribs*. A **warp-rib weave** is an extension of a plain weave in its picks. In order to illustrate the construction of these weaves, Fig. 35, which shows a warp-rib weave, has been divided into two sections (*a*) and (*b*). In (*a*), all the odd numbered ends float over the filling for

4 picks, while the even-numbered ends are down. In (*b*), the reverse is the case; that is, the even-numbered ends float over the filling, while the odd-numbered ends are under the filling. With this class of weaves, a distinct line is formed across the cloth by means of the ends covering the filling. Thus in Fig. 35 (*a*), for the 4 picks in which the odd-numbered ends are over the filling the ends will have a tendency to crowd together, especially if there are more ends than picks per inch in the weave, as there should always be in a warp-rib weave; that is, the first and third ends will cover the 4 picks of filling that are raised over the second end; the third and fifth ends for these 4 picks will cover the filling that is raised over the fourth end; the fifth and seventh ends will cover the filling that is raised over the sixth end; and the seventh and first ends will cover the filling that is raised over the eighth end. For the next 4 picks the reverse will be the case; that is, in (*b*) the second and fourth ends will cover the filling that is raised over the third end; the fourth and sixth ends will cover the filling that is raised over the fifth end, and so on. Consequently, in these 8 picks two distinct lines will be formed across the cloth because of different ends covering the filling in these two sections. This weave repeats on 2 ends and 8 picks, but four repeats of the weave in the ends are shown here in order that the construction of the weave may be understood more clearly.

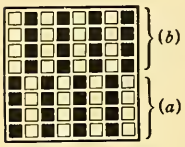


Fig. 35

16. Filling-rib weaves are the exact opposites of warp-rib weaves. As the filling covers the ends in these weaves, ribs are formed lengthwise of the cloth, and for this reason the cloth should always contain more picks per inch than ends. Fig. 36 is an illustration of a filling-rib weave. In (*a*), all the odd-numbered picks float over the 4 ends, while all the even-numbered picks are under the ends. In this case, the first and third picks will crowd over

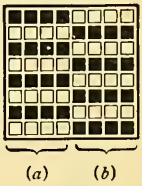


Fig. 36

the ends that are up on the second pick and completely cover them; the third and fifth picks will cover the ends that are raised on the fourth pick; the fifth and seventh picks will cover the ends that are raised on the sixth pick; and the seventh and first picks will cover the ends that are raised on the eighth pick, thus showing a distinct line of filling floats lengthwise of the cloth. In (*b*) the exact reverse is the case; that is, all the even-numbered picks are raised over the ends, while the ends are raised on the odd-numbered picks. By this means the second and fourth picks will cover the ends that are raised on the third pick; the fourth and sixth picks will cover the ends that are raised on the fifth pick, and so on, thus forming another rib of filling floats lengthwise of the cloth. This weave is complete on 2 picks and 8 ends, four repeats of the weave in its picks being shown here.

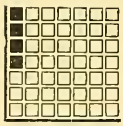
In warp-rib weaves the filling, and in filling-rib weaves the warp, is usually considerably coarser than the other series of yarn, in order to accentuate the ribbed effect in the cloth. In cloths woven with warp-rib weaves, there should be more ends than picks, and with filling-rib weaves, more picks than ends per inch.

17. Unequal Rib Weaves.—In Figs. 35 and 36, the ribs formed by the weaves are of equal size. This is not always the case, however, for **unequal rib weaves** are frequently used. Fig. 37 is an illustration of a weave of this kind. In the lower section, the odd-numbered ends float for 5 picks, while in the upper section the even-numbered ends float for only 3 picks. In this case there are two ribs of unequal size across, one rib being the width of 5 picks, while the other is the width of 3 picks. Unequal filling-rib weaves are formed in the same manner; that is, by having the filling float over an unequal number of ends.

Fig. 37

CORKSCREW WEAVES

18. Corkscrew weaves may be considered a class of rib weaves; but while in rib weaves the ribs extend in a straight line either across the cloth or lengthwise of it, in corkscrew weaves the ribs from a twill line, and for this reason are sometimes known as *corkscrew twills*. Although these weaves may be formed on any number of ends or picks above 5, the best effects are obtained with weaves complete on an uneven number of ends and picks. One method of making a corkscrew weave that will be found as simple as any is as follows: Suppose that it is desired to form a corkscrew weave that will be complete on 7 ends and 7 picks. Divide 7 into two numbers one of which will be larger than the other by 1—in this case 3 and 4—then take 3 down and 4 up as the basis on which to mark each end in the corkscrew weave. The first end, as shown in Fig. 38 (*a*), will be lowered for 3 picks and raised for 4 picks. For the second end of the weave, begin on the first pick on which the first end is raised and mark the second end 4 up and 3 down, counting down. For the third end of the weave, commence on the first pick on which the second end is raised and mark 4 up and 3 down, counting down. Continue in this manner until the weave is complete. Corkscrew weaves that are complete on an odd number of picks will always be complete on the same number of ends as picks. Thus, in the case under consideration, since the weave is complete on 7 picks it will also be complete on 7 ends. The complete weave is shown in Fig. 38 (*b*). This weave is termed a *warp corkscrew*, since the warp ends cover the filling and, consequently, nothing but warp shows either on the face or the back of the cloth. In order that these weaves may appear to best advantage, it is necessary, as in the case of warp-rib weaves, to have more ends than picks per inch. Any warp corkscrew weave when turned quarter way around will give a filling corkscrew weave.

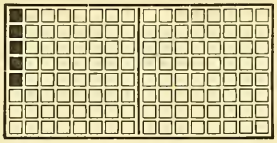


(*a*)

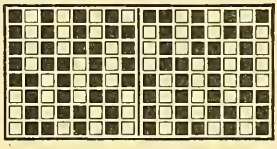
(*b*)

FIG. 38

Warp corkscrews made on an even number of ends and picks will not repeat until carried out for twice as many ends as picks. In constructing these weaves the number that represents the number of picks on which the weave is complete must be divided into two numbers, one of which will be larger than the other by 2. Suppose, for an example, that it is desired to construct a corkscrew weave that will be complete on 8 picks. The two numbers into which 8 is divided are 5 and 3. Mark the first end of the weave 3 down and 5 up, as shown in Fig. 39 (*a*). For the second end of the weave, commence on the first pick on which the first end is raised and raise the second end on this pick and also on all the picks on which the first end is lowered. The second end will therefore be up 4 picks and down 4 picks, whereas the first end is down 3 picks and up 5 picks. Marking the third end in the same manner as the second, this end will be up for 1 pick, down 3, and up 4 picks; it will thus be similar to the first end with regard to the length of the floats. The complete weave is shown in Fig. 39 (*b*). Since the ribs of this weave are formed by the ends that are raised crowding over the filling, two ribs will be formed diagonally across the cloth, one of which will be the width of 5 picks, while the other will be the width of only 4 picks.



(*a*)



(*b*)

Fig. 39

Fig. 40

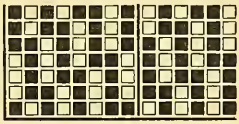


Fig. 41

19. Corkscrew weaves are often formed from twills: (1) by rearranging the ends or picks of a regular 45° twill; (2) by combining two twills end and end or pick and pick. Considering first the formation of corkscrew weaves by rearranging the ends of a regular 45° twill, suppose that it is desired to rearrange the ends of Fig. 40 in satin

order on a base of 4 to form a corkscrew weave. This will result in the corkscrew shown in Fig. 41, which gives two repeats of the weave in its ends. By rearranging the ends of a weave in this manner *warp corkscrews* are formed, while by rearranging the picks *filling corkscrews* are formed. Corkscrew weaves cannot readily be formed by rearranging the ends of every 45° twill; weaves similar to that shown in Fig. 40 are most suitable for this purpose.

When combining twills end and end or pick and pick to form a corkscrew weave, care should be taken to select such weaves as will give the desired effect. Figs. 42 and 43

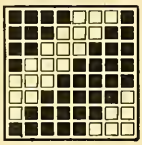


FIG. 42

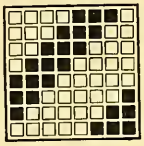


FIG. 43

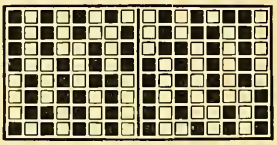


FIG. 44

show two 8-end twills that it is desired to combine end and end to form a corkscrew weave. Fig. 44 shows a weave formed in this manner; the first end of Fig. 44 is the first end of Fig. 42; the second end of Fig. 44 is the first end of Fig. 43; the third end of Fig. 44 is the second end of Fig. 42; the fourth end of Fig. 44 is the second end of Fig. 43, and so on for the 16 ends. By combining these two twills, the ends of which have different lengths of floats, there is formed a corkscrew twill that will have ribs of unequal size running diagonally across the cloth, since all the odd-numbered ends are up 5 picks and down 3 picks, while the even-numbered ends are up 3 picks and down 5 picks.

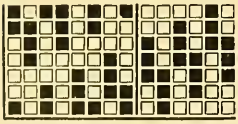


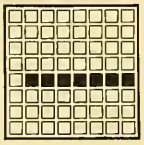
FIG. 45

20. Another class of corkscrew weaves includes those known as *warp corkscrews with filling effects.* These weaves may be formed by taking the ends of any filling-flush twill in such a manner as to form ribs in a twill line

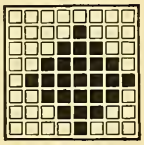
across the cloth and at the same time show a distinct line of filling floats. Fig. 45 is such a weave, constructed by taking the ends of the regular 45° 7-end twill $\frac{3}{4}$ in 1, 6, 2, 7, 3, 1, 4, 2, 5, 3, 6, 4, 7, 5 order.

HONEYCOMBS

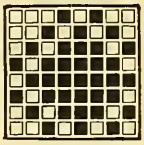
21. Honeycomb weaves are very common and are extensively used in making towels. When coarse, soft-twisted yarns are employed they make a spongy cloth well suited to this purpose. It is possible to make honeycomb weaves on any number of ends from 4 upwards, but the best effects are obtained with an even number of ends. When making these weaves the first thing to be decided on is the number of ends to be used. Suppose that it is desired to make a honeycomb weave on 8 ends and 8 picks. Raise all the ends, except the first, on any one pick of the weave, preferably one near the center of the design, as shown in Fig. 46 (*a*), in which the fourth pick has been selected and all the ends raised except the first. Next form a warp spot by marking the risers in regular 45° order from the first and last ends, as shown in Fig. 46 (*b*). After the spot has been formed, run a line of risers around it, leaving one blank space between these risers and those forming the spot, and confining this line of risers to 8 ends and 8 picks. On the pick shown in (*a*), which is the fourth pick in (*b*), no riser can be added to those in the spot figure, since it would not be possible to have a blank space between them; consequently, commencing with the next, or fifth, pick, mark the first end, which will leave a blank space between it and the first end marked in the spot figure on this pick. Running up this line in a regular 45° manner, it stops on the fourth end on the eighth pick. Continuing this line of risers completely around the spot, Fig. 46 (*c*) is obtained.



(*a*)



(*b*)



(*c*)

FIG. 46

EXAMPLES FOR PRACTICE

1. Make a twill weave with the base $\frac{3}{3}\frac{2}{2}\frac{1}{1}$.

2. From the weave given in answer to question 1 construct a weave by taking the ends in satin order, moving in sevens.

3. Construct a 15-end twilled basket.

4. Construct a rib weave that will make uneven ribs across the cloth.

5. Construct a rib weave that will make even ribs lengthwise of the cloth.

6. Make a twill weave with the base $\frac{3}{7}$, and from this twill construct a warp corkscrew weave; state the order in which the ends of the twill are taken to form the corkscrew.

7. Construct a honeycomb weave on 10 ends.

COMBINATION WEAVES

Serial 508 Edition 1

INTRODUCTION

1. One of the most common methods of producing new or novel weave effects in a fabric is by combining two or more weaves as a whole. In this method of amalgamating weaves, one or more repeats of each weave are joined together, instead of combining the weaves pick and pick or end and end. As twill, basket, satin, corkscrew or other weaves produce entirely distinct effects in a fabric, a large field is opened by this method for the production of new effects.

In the formation of combination weaves there are two important points that should be taken into consideration. In the first place, the yarns with which the cloth is to be woven, whether woolen, worsted, silk, or cotton, must be considered. If the yarn is woolen, the weaves must be uniform in structure, as woolen yarn is so constructed that it is not especially adapted for developing weave effects, the surface of the yarn being too rough and fibrous. Simple combinations and good colorings are the essential points in woolens.

In worsted or cotton fabrics, a large diversity of fancy weaves may be used, since the yarns are comparatively smooth (the fibers being laid in parallel order) and are thus excellently adapted for bringing out every detail of the weave. Silk is a still more suitable yarn for developing weave effects.

The second point, to which it is especially desired to call attention, is that however widely the weaves that are to be

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combined may differ in respect to the effects that they produce in the cloth, they must be somewhat similar as regards the number of interlacings of the warp and filling, otherwise they cannot be made to weave together evenly. When desiring to form new effects by the method of combining two or more weaves, this latter fact should constantly be borne in mind, as it is absolutely essential to the satisfactory weaving of the cloth.

2. Fig. 1 is a representation of a sample of cloth made by combining two weaves without regarding the number of interlacings of warp and filling. The ends in (*a*) are interlaced on the 6-end-basket principle, while those in (*b*) are working plain, so that the ends in (*a*) interlace with the filling only four times in the 12 picks shown in this figure, while the ends in (*b*) interlace twelve times during the same number of picks. The result of this will be a tendency to prevent the picks of (*b*) from being as closely pressed against one another as those in (*a*), where the intersections are not so frequent. In (*b*) the warp yarn interlaces at every pick; therefore, the ends lie between one pick and the pick following, separating these by a distance nominally represented by the diameter of the warp yarn, and thereby preventing each pick from being beaten up against the preceding one. In (*a*), there is nothing to prevent one pick from being beaten up against the adjoining one in those places where the picks are three in a shed, supposing, of course, that this weave was being used

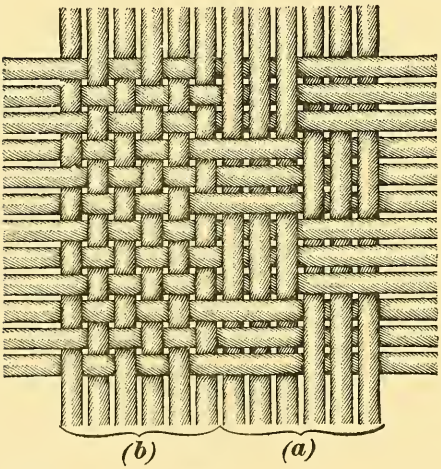


Fig. 1

alone irrespective of the weave used in (*b*); but between the third and fourth, sixth and seventh, ninth and tenth, and also the twelfth and first picks, the warp yarns change positions, and those lying between the third and fourth picks prevent these picks from being beaten up against each other, while the same is true in each of the other cases.

The more frequently the warp and filling interlace with each other, the greater difficulty there will be in driving each pick of filling closely against the preceding one; consequently, if the picks were beaten up close together in (*a*), the warp ends in (*b*) being deflected from a straight line to a much greater extent than those in (*a*), would take up faster and consequently work tighter during weaving, which would soon produce a cockled, or wrinkled, appearance. On the other hand, the more open the weave, the closer can the filling be inserted; for instance, as 3 ends of warp are depressed or elevated during 3 picks in succession in (*a*), this portion of the cloth admits the filling much more freely. For these reasons, closely woven and loosely woven weaves should rarely, if ever, be combined if the warp yarns are all run from the same beam, as they can be made to weave only with great difficulty. There are some instances, however, where unlike weaves may be combined without detriment to the regularity of the fabric, although these are the exception rather than the rule.

The ends and picks must interlace and form the build, or structure, of the fabric in addition to producing a design. Therefore, the practicability of a design in regard to its weaving should always be as carefully considered as the appearance of the woven cloth.

STRIPES AND CHECKS

STRIPE WEAVES

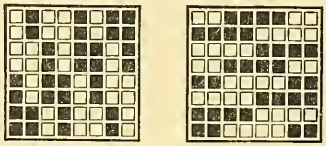
COMBINATIONS OF WARP- AND FILLING-FLUSH WEAVES

3. **Stripes** are continuous effects running lengthwise of the cloth, or in the direction of the warp. The most elementary form of a stripe obtained by a combination of weaves results from combining the warp prunelle with the filling prunelle. Fig. 2 is a stripe design complete on 18 ends resulting from combining these two weaves. The first 15 ends are made by repeating the warp prunelle $\frac{2}{1}$ five times, while the last 3 ends are the filling prunelle $\frac{1}{2}$. In combining weaves in this manner, it is always best wherever possible to make the weaves *cut* where they oppose each other. By **cutting** is meant that, where the weaves join, the warp floats of one weave will oppose, or come against, the filling floats of the other, and the filling floats oppose the warp floats. This has been done in Fig. 2. Thus, the fifteenth end is the last end of the warp prunelle, while the sixteenth end is the first end of the filling prunelle, and on those picks on which the fifteenth end is raised, the sixteenth end is lowered, while on those picks on which the fifteenth end is lowered, the sixteenth end is raised. But there is another joining point of these two weaves besides the fifteenth and sixteenth ends. If the weave should be repeated in its ends, the first end would come next to the last end. Therefore, when seeking to have weaves cut where they are joined, this point should be as carefully considered as the former. Fig. 2 complies with these requirements, since on those picks on which the last end is

Fig. 2

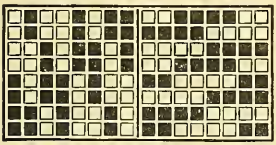
raised, the first end is lowered, while on those picks on which the last end is lowered, the first end is raised.

4. All weaves should run up in regular order and they should not be made irregular for the purpose of making the weaves cut, although they may be commenced on different ends and picks to attain this end. When weaves are combined and it is impossible to make them cut perfectly, always try so to combine the weaves that the warp and filling floats will not be any longer in the combination weave than they were in the separate weaves. To illustrate this point, suppose that it is desired to combine the two weaves shown in Fig. 3 (*a*) and (*b*). In the first case they will be combined just as they are; that is, by copying the 8 ends of Fig. 3 (*a*) for the first 8 ends of the new weave and copying the 8 ends of Fig. 3 (*b*) for the last 8 ends of the new weave. Fig. 4 (*a*) shows the weave formed by combining the two weaves by this method. On the third pick there is a filling float of 6 ends, while in neither of the weaves that were combined was there a filling float of more than 4 ends; also, on the seventh pick, 6 ends are raised side by side, while in neither of the weaves combined were there more than 4 ends up together on the same pick.

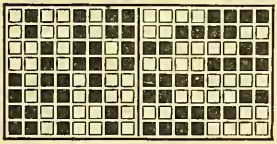


(*a*) (*b*)

FIG. 3



(*a*)



(*b*)

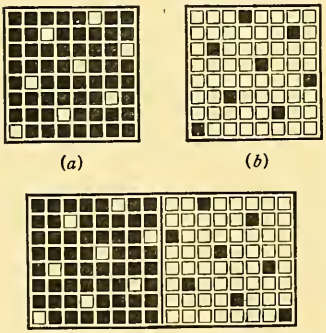
FIG. 4

Fig. 4 (*b*) shows another combination of these two weaves, but in this case on no pick does the filling float over a greater number of ends than it did in either of the weaves combined; neither are more ends raised together on any one pick. In this figure the first 8 ends are Fig. 3 (*a*), taken just as they are, while the last 8 ends are Fig. 3 (*b*), commencing with the seventh end and taking the ends in regular

order; that is, the ninth end of Fig. 4 (*b*) is the seventh end of Fig. 3 (*b*); the tenth end of Fig. 4 (*b*) is the eighth end of Fig. 3 (*b*); the eleventh end of Fig. 4 (*b*) is the first end of Fig. 3 (*b*); the twelfth end of Fig. 4 (*b*) is the second end of Fig. 3 (*b*), and so on.

It is not always possible so to combine two weaves that they will cut perfectly, nor in some cases so that there will not be any longer floats than in the individual weaves themselves; but the best manner of combining them should always be sought, since, if combined well, the resulting weave has a much better effect in the cloth. A description of the formation of a few of these weave combinations will be given in order to enable the method employed to be thoroughly understood.

5. One method of combination that is as satisfactory as any for certain classes of weaves is to combine two weaves, one of which is the reverse of the other in regard to the warp and filling flushing. These weaves can always be made to cut where they are joined. Thus, for example, suppose that two 8-end satin weaves are to be combined on this basis. Fig. 5 (*a*) shows an 8-end warp satin moving on a base of 3, while Fig. 5 (*b*) shows an 8-end filling satin moving on a base of 5. In making a combination weave from warp and filling satins, in order to have the weaves cut it is necessary to have the sum of the numbers used for the bases of the satins equal to the number of ends on which each satin weave is complete. Thus, in the case of Fig. 5 (*a*) and (*b*) the warp satin moves on a base of 3 while the filling satin moves on a base of 5, and $5 + 3 = 8$, which is the number of ends on which each satin weave is complete.



(*a*) (*b*) (*c*)

Fig. 5

It is next necessary to combine these two weaves in such a manner that they will cut, and since, if they were combined

as shown in Fig. 5 (*a*) and (*b*), the desired result would not be obtained, it will be necessary to start one of the weaves on either a different end or a different pick. By copying Fig. 5 (*a*) just as it is for the new weave, and starting Fig. 5 (*b*) on the second end, the weaves will be made to cut. Fig. 5 (*c*) shows these two weaves combined in this manner. Dealing with the second section of Fig. 5 (*c*) alone, the ninth end is the second end of Fig. 5 (*b*); the tenth end, the third end of Fig. 5 (*b*); the eleventh end, the fourth end of Fig. 5 (*b*); and so on.

6. Another good method of forming combination weaves with warp- and filling-flush weaves is to combine two twill weaves in one of which the warp flushes to an extent equal to the filling flushes of the other weave. Fig. 6 (*a*) and (*b*) are two such twill weaves, and by combining them as shown in Fig. 6 (*c*), they form a weave that cuts perfectly where the two weaves are joined. In Fig. 6 (*c*), both of the weaves that are combined have been repeated in both ends and picks.

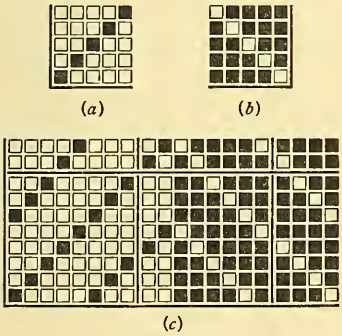


Fig. 6

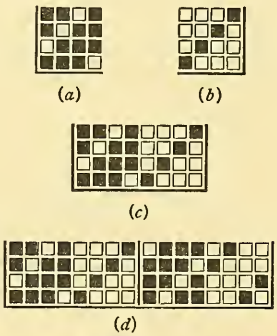


Fig. 7

In these figures, the twill in one figure runs in a direction opposite to the twill in the other; that is, the twill in Fig. 6 (*a*) runs to the right, while that in Fig. 6 (*b*) runs to the left. If it is desired to combine warp- and filling-flush twills in which the twill lines run in the same direction, it will be found necessary either to continue the weaves as a whole or else to continue one of the weaves for a portion of a repeat, in order to make them cut. For instance, suppose

that it is desired to combine Fig. 7 (*a*) with Fig. 7 (*b*) so that the width of each section of the stripe will be equal; that is, so that each will contain one repeat of the weave, or 4 ends in this instance. If this weave is made as shown in Fig. 7 (*c*), a perfect cut is not obtained between the eighth and first ends, but if it is continued as shown at Fig. 7 (*d*), the last, or sixteenth, end will cut perfectly with the first, and perfect cuts will also be made at all the other places where the warp-flush weave joins the filling-flush weave, or vice versa. In each section of Fig. 7 (*d*), the weaves shown in Fig. 7 (*a*) and (*b*) are used, but the sections that have been repeated are started on different ends, so as to make perfect cutting possible.

Another method of obtaining a perfect cut in a case like this is to continue one section for a number of ends sufficient to make a perfect cut; thus, 2 extra ends are added to the filling-flush weave in Fig. 8, or, in other words, a repeat and a half of this weave is used, which makes the last end of the weave work exactly opposite to the first, thus insuring a perfect cut. This method makes one stripe, in this case the filling-flush stripe, wider than the other. If even stripes are desired and the method employed in Fig. 7 (*d*) cannot be used, perfect cuts can be made by adding 1 end to both the warp- and the filling-flush section of the weave, as shown in Fig. 9. In this case a perfect effect in the cloth will be obtained, although even repeats of each weave will not be shown, each section having 1 end in excess of a repeat.

Fig. 8

Fig. 9

COMBINATIONS OF EQUALLY FLUSH WEAVES

7. Very frequently stripe weaves are formed by using an equally flush twill as a chain draft and arranging the drawing-in draft so as to produce the required stripe effect. Fig. 10 (*a*) shows a stripe weave made in this manner, in which the first 4 ends are the cassimere twill $\frac{2}{2}$; the next 2 ends have the same interlacings as the second end; the

next 2 ends have the same interlacings as the fourth end; the next 8 ends are the regular twill commencing with the second end; the next 2 ends have the same interlacings as the third end; the next 2 ends have the same interlacings as the first end; while the last 2 ends are the cassimere twill commencing with the third end and running in regular order. It will be noticed that the last 2 ends are a continuation of the first 4 ends; that is, the last end does not cut with the first end but continues the weave regularly.

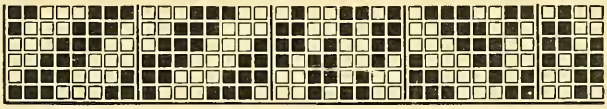
(*a*)

(*b*)

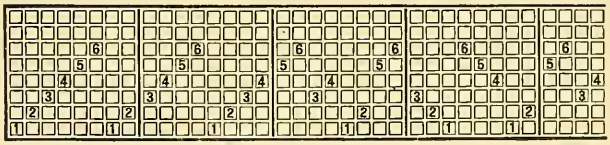
Fig. 10

In all other places where this weave changes, the ends cut. By this means a perfect stripe is obtained that is the same as though the $\frac{2}{2}$ basket were combined with the cassimere twill, yet the stripe may be obtained by using the cassimere twill as the chain draft and drawing the warp ends through the harnesses, as indicated by the drawing-in draft shown in Fig. 10 (*b*).

Fig. 11 (*a*) is another stripe weave formed in a similar manner from the equally flush twill $\frac{3}{3}$. The first 18 ends of this stripe design are formed by running the regular twill $\frac{3}{3}$



(*a*)



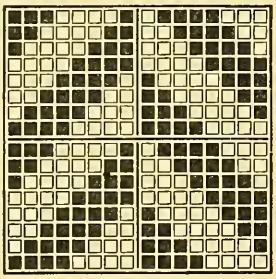
(*b*)

Fig. 11

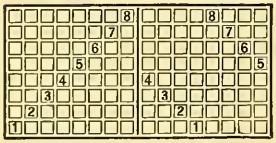
in regular order; the next 2 ends are the same as the third and fourth ends of the twill; the next 2 ends are similar to the first and second; and the next 2 ends are similar to the

fifth and sixth. The next 6 ends are the regular $\frac{3}{3}$ twill with the twill running in the opposite direction, and commencing with the third end. The next 2 ends are the same as the first and second ends; the next 2 ends are similar to the fifth and sixth; while the last 2 ends are similar to the third and fourth. In this case, as in the previous one, each end in Fig. 11 (*a*) is a certain end of the regular $\frac{3}{3}$ twill, and, consequently, it is possible to weave this design on 6 harnesses. The harness draft for Fig. 11 (*a*) on 6 harnesses is shown in Fig. 11 (*b*).

8. Another method of forming stripe weaves, and one that is quite generally adopted, is that of running a regular equally flush twill up for a certain number of ends and then reversing the weave, but commencing with an end that will cause the weave to cut where it is reversed. This effect may be obtained by using a regular equally flush twill weave as a chain draft with an angled drawing-in draft.



(*a*)



(*b*)

FIG. 12

Fig. 12 (*a*) shows a weave of this class, while Fig. 12 (*b*) gives the harness draft, which, it will be noticed, is an angled draft. In Fig. 12 (*a*), the weave is repeated in its picks, since 16 picks are shown, although the weave is really complete on 16 ends and 8 picks. At the ninth end it is reversed, and this end is the same as the fourth end; the weave also cuts at this point, as the warp and filling floats of the eighth end oppose the warp and filling floats of the ninth end. The warp and filling floats of the first end also oppose the warp and filling floats of the last end, thus causing the weave to cut at this point, since these 2 ends come together in the cloth.

The width of either section of the stripe can readily be changed by repeating that section of the drawing-in draft.

Thus, if the first 8 ends of the drawing-in draft were repeated four times and the last 8 ends were not repeated, the first section would be complete on 32 ends and the last section on 8 ends, the whole weave being complete on 40 ends, although it would require only the same number of harnesses to weave it, namely 8 harnesses. By changing the drawing-in draft in this manner, a large number of different weaves can readily be formed, and by changing the twills in the weave, a still greater variety can easily be obtained.

SINGLE-END STRIPES

9. Another class of stripe designs that is met with quite frequently includes weaves known as **single-end stripes.** These weaves are generally formed by opposing a warp-flush weave with a single end of a filling-flush weave, or vice versa, having the ends cut where the two weaves oppose each other; the effect of this is to form a *cut mark*, or fine indented line, which is generally arranged to run warp way of the cloth. Fig. 13 illustrates one of these weaves; the first end is an end of a filling-flush weave; the next 6 ends are the regular $\frac{2}{1}$ warp-flush twill; the next end is a filling-flush end; the next 6 are the $\frac{2}{1}$ twill; the next end is a filling-flush end; and the last 3 are the $\frac{2}{1}$ twill.

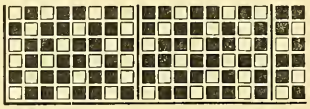


Fig. 13

Where the weaves are combined they cut on both sides of the single end, and in order to accomplish this it is necessary to have the end on one side of the single end of the filling flush exactly like the end on the other side. Thus, the seventh and ninth ends of the weave illustrated are the same, also the fourteenth and sixteenth, and also the second and eighteenth.

EXAMPLES FOR PRACTICE

1. Make a stripe design on 12 ends by reversing the 6-end twill $\frac{3}{3}$: have the weaves cut where they reverse.

2. Make a single-end stripe design on 20 ends, using the 4-end twill $\frac{3}{1}$.

3. Make a stripe design on 14 harnesses, using warp- and filling-flush satins; have the weaves cut where combined.

4. Make a stripe design on 20 ends, using the 5-end warp and filling satins repeated in the ends.

5. Give a harness draft complete on 24 ends that will give a stripe effect in the cloth when using the $\frac{6}{6}$ twill for a chain draft.

CHECK-WEAVES

COMBINATIONS OF EQUALLY FLUSH WEAVES

10. **Check-weaves** may be made in a variety of ways, many of these weaves having a twill or satin base. In many cases the figure on one part of the check will be found to be produced by the warp, while the figure on the other part will be produced by the filling. Check-weaves to a certain extent may be considered as simply extensions of stripe weaves. It has been explained how a stripe may be formed in the cloth by opposing one weave with another; if, after this is done, the weave should be extended in its picks, taking pains to have the picks oppose one another in the same way as the ends were opposed in the stripe weave, the resulting figure will form a check in the cloth.

11. Suppose, for example, that it is desired to make a check-weave with the regular equally flushed weave shown in Fig. 14 (*a*) as a base. First, it is necessary to form a stripe design from the regular twill. Fig. 14 (*b*) shows the stripe design formed from the regular twill shown in Fig. 14 (*a*). The formation of this weave agrees with the descriptions given, and the harness draft for it will be an angled draft. Next consider the stripe as two separate sections, that is, the first 6 ends will be one section and the last 6 ends will be another, after which extend each section in its picks, taking care to have the weaves cut in the picks the same as in the ends when forming the stripe. In other words, extend each section as if it were to form a stripe across the cloth instead of lengthwise. Fig. 14 (*c*)

shows the first 6 ends extended in this manner, while Fig. 14 (*d*) shows the last 6 ends extended. The weaves cut perfectly in their picks, since in both weaves the sixth pick opposes the seventh, and the first and last picks oppose each other. In actual practice the picks in each of the two sections of the weave, as shown in Fig. 14 (*b*), would be run up without separating the weaves; they have been separated here simply to make the process clearer. Therefore, the complete check-weave will be the weave shown in Fig. 14 (*e*), which is Fig. 14 (*c*) and (*d*) brought together.

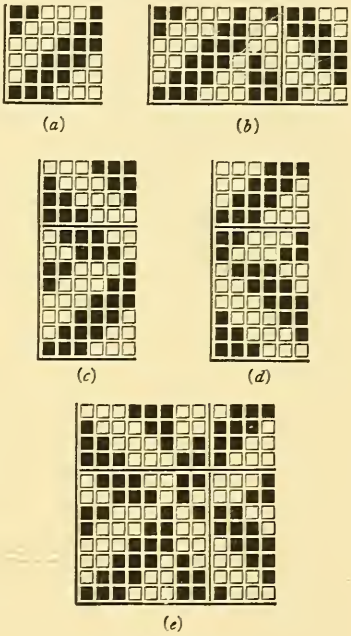


Fig. 14

An important point that should be noted in connection with this check is that the weave cuts all around; that is, the sixth pick opposes the seventh pick; the sixth end opposes the seventh end; and, further, the first and last picks, and also the first and last ends, oppose each other. This feature should be present in check-weaves formed in this manner.

The same harness draft that would be used in connection with the weave shown in Fig. 14 (*b*) would also be used for the weave shown in Fig. 14 (*e*). Therefore, in actual practice, when it is desired to change a stripe weave to a check, all that is necessary is simply to alter the chain draft to give the desired effect. With stripes formed on this principle, the size of the stripe can be enlarged to any desired extent by simply altering the drawing-in draft. The same rule holds good when dealing with checks formed in this manner, with the exception that in the latter case the chain draft must also

be altered, that is, the size of the check may be increased as desired by changing the drawing-in draft and chain draft to suit the requirements. Fig. 15 illustrates a design formed by this method of enlarging a check-weave; it has been formed by simply extending each section of Fig. 14 (*e*) in both ends and picks. Take, for example, the section occupying the lower left-hand corner in both Figs. 14 (*e*) and 15. Both of these weaves are the same, the only difference being that while in one case the weave occupies 6 ends and 6 picks, in the other it occupies 12 ends and 12 picks. The same has been done with each of the four sections, thus causing the new weave to occupy 24 ends and 24 picks, where it originally occupied but 12 ends and 12 picks. The weave shown in Fig. 14 (*e*) can be made on 6 harnesses, which is the same number on which Fig. 15 can be woven.

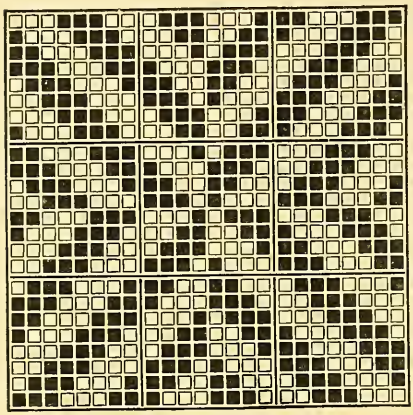


Fig. 15

12. Stripes may be formed in a variety of ways, not only by equally flushed twills but also by opposing a warp-flush twill with a filling-flush twill. The same is equally true of checks and, consequently, a check-design may readily be formed from a stripe design that has been obtained by combining warp- and filling-flush twills. Fig. 16 is an example of this type of check-designs. The first 8 picks of this design alone form a stripe design, obtained by combining the warp-flush twill $\frac{3}{1}$ with the filling-flush twill $\frac{1}{3}$.

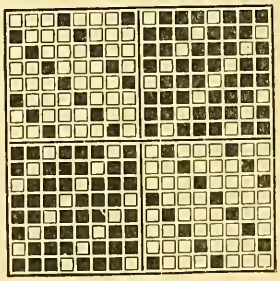


Fig. 16

The next 8 picks are formed by opposing the warp-flush section with the filling-flush weave and the filling-flush section with the warp-flush weave. This weave cuts perfectly at all points.

13. Warp- and filling-satin weaves are often combined to form stripe weaves, and these also may be extended to check-weaves and made to cut at all points. Fig. 17 is an example of a cut check-weave made from warp and filling satins. When combining weaves of this class to form a check, the explanations given for stripe weaves made by combining satins should be carefully noted, especially with regard to the relation that the base of the warp satin should bear to the base of the filling satin in order to make the weaves cut at all points, and also with regard to starting the weaves on certain ends and picks for the same purpose. In Fig. 17, the eighth and ninth ends and the first and last ends, also the eighth and ninth picks and the first and last picks, cut perfectly, since in each case the warp and filling floats of one weave oppose the filling and warp floats of the other.

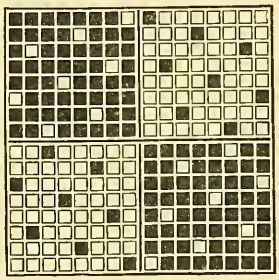


FIG. 17

It will be found advantageous to practice making these weaves, as well as all weaves that are explained in this Course, as it is only by constant practice that familiarity with the methods employed can be obtained. In making a check-weave, it is simply necessary to decide on the weave that is to form the base and run this weave up for as many ends and picks as desired. From this weave, form a stripe design by following the explanations given for stripes and afterwards extending the weave in its picks to form a check, always being careful, however, to see that the weaves cut at all points. Check-weaves constructed after the manner of Figs. 16 and 17 are known as **diaper weaves.**

CHECKS FORMED BY REVERSING

14. Another method of forming checks is by means of what is termed **reversing**, or **transposing**, and consists of taking any simple weave as a base and combining it with a weave that contains filling floats where the original weave has warp floats and warp floats where the original has filling floats. The combination of these weaves will make a stripe from which a check may be formed by reversing or transposing the stripe design in the same manner as the original weave was transposed to obtain the stripe.

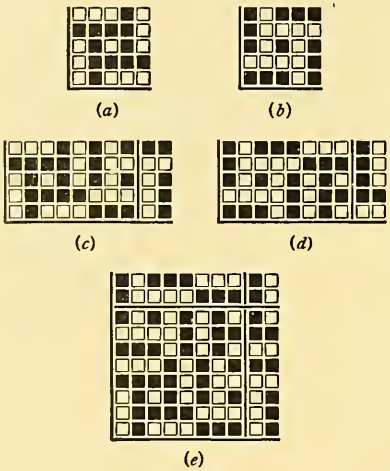
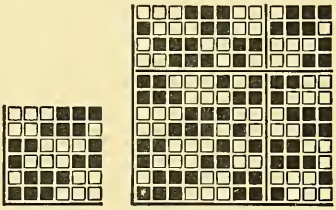


FIG. 18

To illustrate this method of forming checks, suppose that it is desired to form a check-weave using the weave shown in Fig. 18 (*a*) as a base. This figure occupies 5 ends and 5 picks; taking the next 5 ends and 5 picks across the design paper, fill in those squares that correspond to the squares left blank in the original figure, leaving blank those squares that were filled in in the original figure. In order to make this somewhat plainer, the weave will be made from Fig. 18 (*a*), keeping the weaves separate, although in reality they should be combined when making the stripe design. Fig. 18 (*b*) shows the weave obtained by transposing the weave shown in Fig. 18 (*a*). In transposing a weave in this manner to form a stripe, the first end of the new weave is to be the reverse of the last end of the original weave; the second end of the new weave is to be the reverse of the next to the last end of the original; and so on.

Considering Fig. 18 (*a*) and (*b*), the last, or fifth, end of Fig. 18 (*a*) is lowered on the first pick, raised on the second

pick, and lowered on the third, fourth, and fifth picks. The first end of Fig. 18 (*b*) is exactly the reverse, since it is raised on those picks on which the fifth end of Fig. 18 (*a*) is lowered, and is lowered on those picks on which the fifth end is raised. The fourth end of Fig. 18 (*a*) is exactly the reverse of the second end of Fig. 18 (*b*), since on those picks on which one end is raised the other end is lowered, and also on those ends on which one end is lowered the other end is raised. The same is true with the third end of Fig. 18 (*a*) and the third end of Fig. 18 (*b*); with the second end of Fig. 18 (*a*) and the fourth end of Fig. 18 (*b*); with the first end of Fig. 18 (*a*) and the last end of Fig. 18 (*b*). Thus, if these two weaves were combined to form a stripe, they would be found to cut perfectly. Fig. 18 (*c*) shows the stripe weave formed in this manner.



(*a*) (*b*)

Fig. 19

It next becomes necessary to form a check-design from the stripe shown in Fig. 18 (*c*). In order to form this weave, the stripe must be extended in its picks by reversing the picks. This will be dealt with in the same manner as when forming the stripe from the original weave. Fig. 18 (*d*) shows the weave formed from the stripe that must be combined with it to make the check. This weave is formed by reversing the picks of Fig. 18 (*c*) in the same manner as Fig. 18 (*b*) was formed by reversing the ends of Fig. 18 (*a*). Thus, the first pick of Fig. 18 (*d*) is the reverse of the fifth pick in Fig. 18 (*c*); the second pick of Fig. 18 (*d*) is the reverse of the fourth pick of Fig. 18 (*c*); the third pick of Fig. 18 (*d*) is the reverse of the third pick of Fig. 18 (*c*); and so on for all the picks.

By combining these two weaves, the check-design shown in Fig. 18 (*e*) is obtained, which cuts at all points. Fig. 19 (*a*) is another base from which to form a check-weave after the manner described, while Fig. 19 (*b*) shows the completed weave. This weave also cuts at all points—a feature that

is always desirable with these weaves. Check-weaves are produced by a variety of methods. It is not necessary always to have the different weaves that form the check cut perfectly, although much neater and clearer effects are produced when this is the case.

COMBINATIONS OF WEAVES OF DIFFERENT STRUCTURE

15. Another method of forming check-weaves is that of combining different weaves in such a manner that distinct effects will be formed in the cloth, so arranged that the whole will produce a check. Fig. 20 shows a check-weave formed in this manner. The whole figure may be divided into four parts; namely, the lower left-hand corner, the

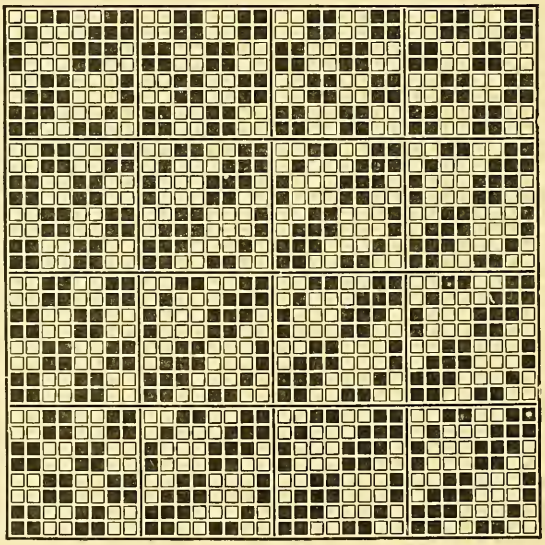


FIG. 20

lower right-hand corner, the upper left-hand corner, and the upper right-hand corner. The weave in the lower left-hand corner is the regular 4-end basket repeated twice in its ends and six times in its picks; the weave in the upper right-hand corner is the same, but instead of occupying the same number of ends and picks in this case, it is repeated

six times in its ends and twice in its picks. The weave in the upper left-hand corner is a fancy twill complete on 8 ends and 8 picks, while in the lower right-hand corner the same weave is repeated three times in both ends and picks. By combining these weaves in this manner, a distinct check

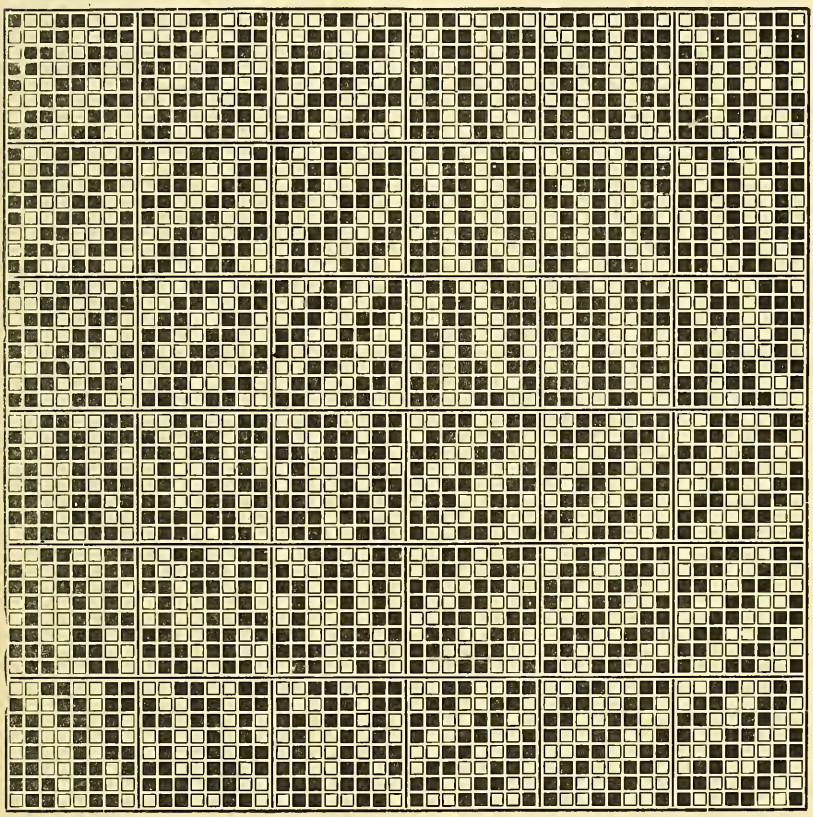


Fig. 21

effect is formed in the cloth, and they cut perfectly where joined. Although this weave occupies 32 ends and 32 picks, it is possible to draft it down to 16 harnesses.

Checks formed by combining different weaves in this manner are more difficult to construct than those previously

described, on account of the difficulty in finding weaves of different constructions that will cut perfectly. In all cases, perfect cuts are not obtainable in this class of checks, but the joining places should always be made as perfect as possible and the weaves should be combined in such a manner that the floats of warp or filling will not be any longer than possible.

16. Check-weaves are sometimes formed by combining twill weaves that form different angles in the cloth. Fig. 21 is an example of this class of weaves, in which the check is formed by combining a cassimere twill that makes an angle of 45° with a fancy upright twill complete on 8 ends and 8 picks. The weave is complete on 48 ends and 48 picks, but can be drawn and woven on 16 harnesses. Check-weaves made on this principle can very rarely be made to cut perfectly all around, as is the case with Fig. 21.

WEAVES RESULTING FROM OTHER COMBINATIONS

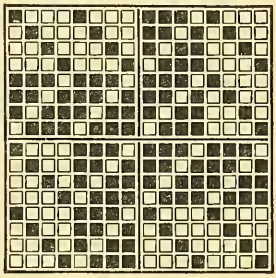
WEAVES FORMED FROM MOTIVES

17. When weaves are to be combined so as to produce a more or less elaborate pattern instead of a simple arrangement as in stripes and checks, the order or method of their arrangement is usually indicated by a *motive*. A **motive** as considered in this connection is a weave figure that shows the arrangement of the separate weaves in the combination weave. It may be defined as a plan, or skeleton, of the desired pattern that may be enlarged into an extensive design; the motive simply shows the general arrangement of the pattern, but gives no idea of the ultimate extent of the resultant combination weave nor of what weaves are to be combined. In using a motive as a plan for combining weaves, the filled squares of the motive are assumed to represent one of the weaves to be combined and the blank

squares another weave, the combination weave being made of any desired size by extending the motive.

For instance, Fig. 22 (*a*) shows a motive from which it is desired to produce a design that will be complete on 16 ends and 16 picks. The motive occupies 4 ends and 4 picks, and the filled-in squares and the blank squares of the motive represent two distinct weaves. The first item to be determined when constructing a weave from a motive is the number of ends and picks occupied by the weave that is represented by each square of the motive. Thus, since the constructed weave is to occupy 16 ends and 16 picks, while the motive occupies 4 ends and 4 picks, each square of the motive must represent 4 ends and 4 picks of the constructed weave ($16 \div 4 = 4$), or, in other words, the weave represented by each square of the motive must occupy exactly 4 ends and 4 picks, in order to make the constructed weave complete on 16 ends and 16 picks.

(*a*)



(*b*)

FIG. 22

It will be assumed that each blank square of the motive represents the filling crow twill $\frac{1}{3}$, while each filled-in square of the motive represents the warp crow twill $\frac{3}{1}$. It now remains to combine these weaves in such a manner that they will occupy the same relative positions in the constructed weave that the filled-in and blank squares occupy in the motive. Fig. 22 (*b*) shows the weave made in this manner from the motive shown in Fig. 22 (*a*). Comparing these views, the square in the lower left-hand corner of the motive is blank; therefore, the first 4 ends and 4 picks of Fig. 22 (*b*) are composed of the filling crow twill. The next square of the motive counting across the page is marked; therefore, the next 4 ends and 4 picks are composed of the warp crow twill. This method is continued throughout the weave, and the effect when produced in the cloth will be similar to the motive shown in Fig. 22 (*a*).

EXAMPLES FOR PRACTICE

1. Make a check-weave on 16 ends and 16 picks with the $\frac{4}{4}$ twill.

2. Enlarge the weave given in answer to question 1 so that it will occupy 32 ends and 32 picks.

3. Form a check-weave with a 5-end warp-flush and a 5-end filling-flush satin.

4. Form a check-weave by reversing weave 32, *Glossary of Weaves*.

5. Considering weave 200, *Glossary of Weaves*, as a motive, construct a weave on 32 ends and 32 picks, using the filling-flush crow twill weave for the filled-in squares of the motive and the warp-flush crow twill for the blank squares.

FOUR-CHANGE METHOD OF CONSTRUCTING NEW WEAVES

18. New and novel weaves may be constructed from simple foundation weaves by means of what is known as the **four-change method.** Some of the weaves thus obtained will be found to be granite weaves, while others partake of the nature of small fancy twills. In constructing a new weave by four changes, a simple weave of regular structure, such as the cassimere twill, the crow weaves, 6-, 7-, or 8-end twills, etc., should be selected as a foundation. It is also important to select a weave for a base that repeats on the same number of ends as picks. The new weave obtained will always be complete on twice as many ends and picks as the foundation weave; thus, if a weave is used for a base that is complete on 6 ends and 6 picks, the derived weave will occupy 12 ends and 12 picks.

To illustrate this method of originating weaves, suppose that it is desired to construct a new weave from the cassimere twill, Fig. 23 (*a*). Since the cassimere weave is complete on 4 ends and 4 picks, the new weave in this case will occupy 8 ends and 8 picks. The first step is to place the foundation weave on design paper in such a manner that each end of the weave is separated from the next by 1 blank end, and each

pick from the next by 1 blank pick, as shown by the *1*'s in Fig. 23 (*b*). The design paper is then turned one-quarter way around to the right, that is, so that the last end will be in the position of, and considered as, the first pick, and the same weave placed on the design in exactly the same relative position as in the first instance, as shown by the *2*'s in Fig. 23 (*c*). The design paper is then turned a quarter way around again, that is, so that the last pick in Fig. 23 (*b*) will occupy the position of, and be considered as, the first pick, and the weave again placed on the design in exactly the same manner, as shown by the *3*'s in Fig. 23 (*d*). The design

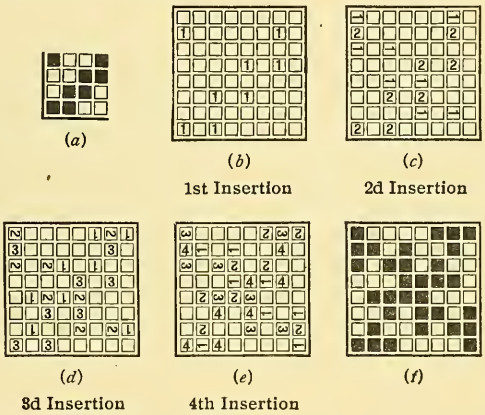


FIG. 23

paper is then turned in the same direction another quarter revolution, so that the first end will occupy the position of, and be considered as, the first pick, and the same weave inserted for the fourth and final time, as shown by the *4*'s in Fig. 23 (*e*). In Fig. 23 (*b*), (*c*), (*d*), and (*e*), numbers are used instead of filled squares, so that each insertion of Fig. 23 (*a*) may be clearly indicated in its proper relative position. Considering each number in Fig. 23 (*e*) to represent a riser, or filled square, the new weave as shown in Fig. 23 (*f*) will result; that is, Fig. 23 (*f*) shows every numbered square in Fig. 23 (*e*) as a filled square, and is the completed derived weave.

Each time a quarter revolution is given to the design paper, the square in the lower left-hand corner is considered

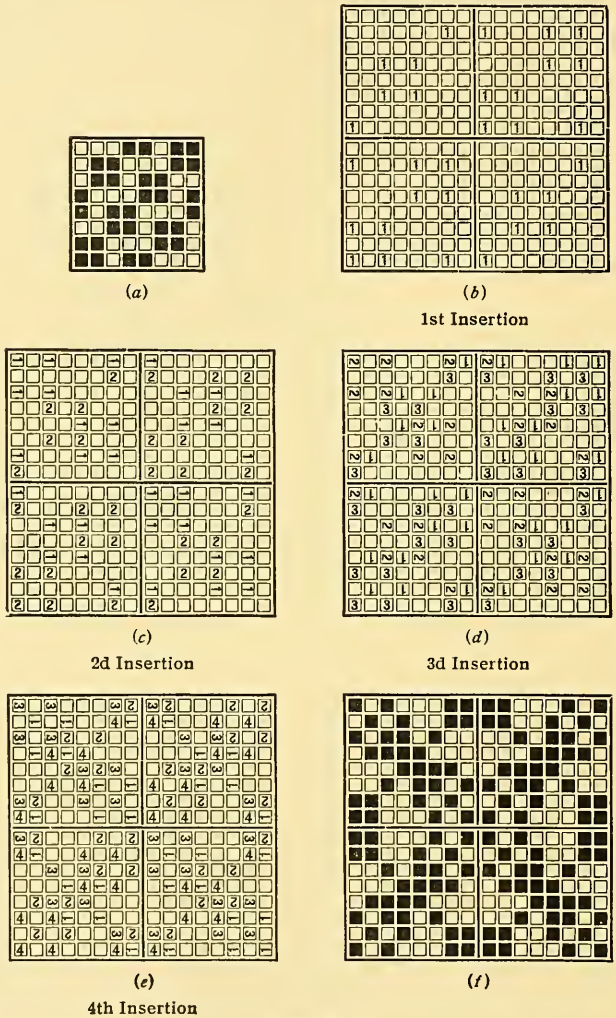


FIG. 24

as the square representing the crossing of the first end and first pick, and the weave is placed accordingly on the design

paper in its proper position. If this is done, and the weave properly inserted each time so that each end and pick is separated by one other end and pick, it will be found that no two marks or risers will fall on the same square, but each will find a blank square of its own in which to be placed. If an equally flushed weave is used as a foundation weave, the derived weave will also show an equal amount of warp and filling on the face, and if the foundation weave is unequally flushed, the derived weave will show the warp and filling on the face in the same proportion as the foundation weave.

19. As a further illustration of this method of originating weaves, suppose it is desired to make a new weave with the 8-end twilled basket, Fig. 24 (*a*), as a foundation weave. Since this weave is complete on 8 ends and 8 picks, the new weave obtained from it will occupy 16 ends and 16 picks. Fig. 24 (*b*) shows the foundation weave opened out and placed on the design paper in the proper manner. Fig. 24 (*c*) shows the weave again inserted in the design but with the last end considered as the first pick. Fig. 24 (*d*) shows the weave inserted the third time, with the last pick considered as the first, while Fig. 24 (*e*) shows the weave inserted for the fourth time, with the first end considered as the first pick, which completes the weave. Fig. 24 (*b*), (*c*) (*d*), and (*e*) are not shown in the same relative position, since, as indicated by the position of the original weave in each figure, the design has been turned one-quarter way around for each insertion of the weave. Fig. 24 (*f*) shows the completed weave, which is a novel fancy diamond effect.

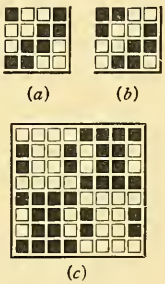
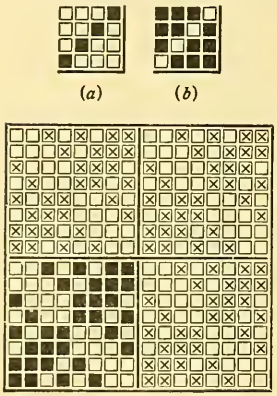


Fig. 25

20. In many cases entirely different effects are produced by using the same foundation weave, but, when inserting it the second and fourth times, commencing on a different pick, so that the relation of the weave to the first and third insertions is changed. For instance, take the effect formed with the cassimere twill as a foundation weave. If this weave

is inserted as shown in Fig. 25 (*a*) the first time, then turned one-quarter way around and the same weave inserted but commenced on the second pick, as shown in Fig. 25 (*b*), then turned again and Fig. 25 (*a*) inserted, and finally turned and Fig. 25 (*b*) inserted, the weave shown in Fig. 25 (*c*) will be obtained. This effect is entirely different from that shown in Fig. 23 (*f*), and yet is produced from the same foundation weave, the relation of the insertions of the foundation weave being changed.



(*a*) (*b*)

(*c*)

Fig. 26

New weaves may also be originated by combining warp- and filling-flush weaves. For instance, suppose that it is desired to produce a new weave using the filling-flush crow weave, Fig. 26 (*a*), and the warp-flush crow weave, Fig. 26 (*b*), as foundation weaves. First, the filling-flush weave is opened out and placed on the design paper, the weave in this case occupying 8 ends and 8 picks. The design paper is then turned one-quarter way around and the warp-flush weave inserted, then another quarter revolution and the filling-flush weave inserted again, and finally another quarter revolution and the warp-flush weave inserted, which results in the weave shown in Fig. 26 (*c*). The weave obtained in this manner may also be varied by commencing one of the weaves on another pick. Fig. 26 (*c*) shows two repeats both in the warp and filling.

EXAMPLES FOR PRACTICE

1. Originate a new weave with the $\frac{2}{1}\frac{1}{2}$ regular twill as a foundation weave.

2. Originate a new weave with the $\frac{2}{3}$ regular twill as a foundation weave.

3. Originate a new weave with the $\frac{3}{2}\frac{2}{1}$ regular twill as a foundation weave.

4. Originate a new weave with the warp- and filling-flush broken crow weaves as foundation weaves.

5. Originate a new weave with the warp- and filling-flush 5-end satin weaves as foundation weaves.

CONSTRUCTION OF SPOT WEAVES

Serial 509 Edition 1

SPOT WEAVES FORMED WITH ONE SYSTEM OF WARP AND FILLING

WARP-SPOT WEAVES

1. Weaves that produce fabrics of a spotted character, that is, cloths with spots distributed over the face, are known as **spot weaves.** These weaves are formed by bringing a certain series of yarn, either the warp or the filling, to the surface of the cloth at certain points and allowing it to float for a number of ends or picks, as the case may be, thus producing a spotted effect on the cloth. The manner in which the yarn is allowed to float on the face will determine the shape and appearance of the spot, and the places where these floats are made will determine the arrangement, or distribution, of the spots on the surface of the fabric. Spots may be made by floating either the warp or the filling on the face of the cloth; the former are known as **warp spots,** and the latter, as **filling spots.**

The first consideration when making a spot weave is the arrangement, or order of distribution, of the spots on the surface of the cloth. Spots may be arranged in plain order, satin order, broken crow order, etc.; by this is meant that the spots appear on the surface of the cloth in the same order that the ends are either raised or depressed in a plain, satin, or broken crow weave, as the case may be. For

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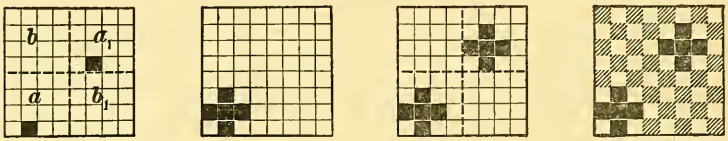
example, if spots are distributed over the surface of a fabric in the same relative position to one another as the risers of the plain weave, they are said to be arranged in plain order, or if they are distributed in the same order as the risers of the 5-end, filling-flush, satin weave, they are said to be arranged in 5-end satin order, etc.

2. To illustrate the method of producing spot weaves, suppose that it is desired to make a warp-spot weave on 8 ends and 8 picks, the spots to be arranged in plain order. Since the spots are to be arranged in plain order, there will be two spots in each repeat of the weave, just as there are two risers in one repeat of the plain weave, and the 8 ends and 8 picks on which the whole weave is to be complete must first be divided into four sections, each containing sixteen small squares of the design paper. Fig. 1 (*a*) represents



(*a*) (*b*) (*c*) (*d*)

FIG. 1

8 ends and 8 picks of design paper thus divided by heavy dotted lines. Since the spots when arranged in plain-cloth order appear on the face of the cloth in a manner similar to the ends in a plain weave, the two spots may be placed in sections a, a_1, while sections b, b_1 are reserved for the ground weave.

Before placing the spots in their respective sections, it is best to mark one of the small squares in each section in which the spots are to be placed, these marks to be placed in squares having the same relative position in each section. Thus, in Fig. 1 (*a*), one square of section a and one of a_1 have been filled in. It is next necessary to determine the spot figure to be used, as a spot must be selected that does not occupy so many ends and picks that two of the spots will run into each other. Since in this case the entire weave is

to be complete on 8 ends and 8 picks, the spot figure cannot occupy many ends and picks, and therefore a simple figure similar to that shown in Fig. 1 (*b*) must be selected.

Although it is not necessary to start the spot weave on any particular end or pick, it must be commenced on the same relative end and pick in both sections *a* and a_1, Fig. 1 (*a*). This is the object of the filled-in squares in each of these sections; that is, to give a starting point when placing the spot figure on the design paper, so that each spot will occupy the same relative position in its section. For example, suppose that the lowest square of the spot is to occupy the square that is marked in section *a*, Fig. 1 (*a*). Then, if this is done in section *a*, it must also be done when placing the spot in section a_1, and by so doing the spots will have the same relative position in the weave and be equally distant from each other; by marking certain squares as in Fig. 1 (*a*), the correct position of the different spots is readily obtained. It next becomes necessary to place the spots on the design paper. The method spoken of, that is, considering the squares marked in Fig. 1 (*a*) as the lowest marked square of the spot, will be adopted in placing this spot on the design paper. Fig. 1 (*c*) shows the spot figure placed on the design paper in this manner; each spot occupies the same relative position in the section in which it is placed, and if three or four repeats of this figure in both ends and picks are worked out, it will also be apparent that there is the same distance between the spots.

3. After the spots have been placed on the design paper, as shown in Fig. 1 (*c*), the blank spaces must be filled in with some simple weave, known as the **ground weave,** in order to give the fabric the required firmness of texture. It would be impossible to construct a fabric exactly as shown in Fig. 1 (*c*), since the fourth and eighth ends and picks are not interlaced with the fabric, and even if the fabric could be thus woven it would be too loosely constructed to be serviceable. When selecting a ground weave to be used with a spot figure, a weave should be selected that will match up well

with the spot; that is, one that will not allow large floats of warp or filling in any part of the cloth. The most useful weaves for this purpose are the plain weave, the twills, and satins. A small, simple, and regular weave can generally be used to the best advantage as a ground weave, and should therefore be selected. It is not always possible to find a weave that will neither run into the spot figure nor leave a larger float in some places than in others. In the example under consideration, it will be assumed that the plain weave is to be used for the ground weave.

In placing the ground weave in a design of this kind, the first square to be marked with a riser should always be carefully selected. Thus, for example, with the illustration being used, suppose that the first riser of the plain weave were marked in the upper right-hand corner of Fig. 1 (*c*); then the next riser would come in contact with a riser in the spot, which should always be avoided, if possible, while, on the other hand, if this next square were skipped without being marked, there would be a float at this point longer than the average float in the rest of the ground weave. However, by beginning the plain weave in the upper left-hand corner and marking this square with a riser, the ground weave will not interfere in any way with the spots. Fig. 1 (*d*) shows the completed weave with the ground inserted in this manner; in no place does the plain weave run into the spot, and the floats of both warp and filling are of an equal length in the ground.

When spots are placed on a plain ground, it will often be found necessary to move one or more spots 1 end or 1 pick out of position, in order to make the plain weave join the spot in the proper manner. This is always advisable when the spots are placed some distance apart, since a slight displacement of the spot will hardly be noticed, while, if the ground weave does not join the spot properly, the entire design is spoiled. Fig. 1 (*d*) serves as an illustration of the manner of constructing spot weaves rather than as an especially meritorious example of such weaves; for, since it is complete on 8 ends and 8 picks, and since two spots have to be placed in this space, it is not possible for the spots to

occupy a very large number of ends and picks, while in order to have a spot weave appear well in the cloth, the spot figure should occupy a comparatively large number of ends and picks. Most spot weaves will, consequently, be found to extend for some distance before repeating. It will also be noted that in many of the spot weaves shown in this Section the spots are placed comparatively close together, but spot weaves are often arranged with the spots a considerable distance apart. The same principles of construction apply, however, as are herein described, and it is only necessary to insert as many ends and picks of the ground weave as desired between the spots in order to distribute them any required distance apart on the face of the cloth.

4. As a further illustration of the method of constructing spot weaves, suppose that it is desired to construct a spot weave on 20 ends and 20 picks and that the spots are to be arranged in 5-end satin order. This will necessitate five spots being placed in one repeat of the weave, and therefore the design paper containing the squares on which the complete weave is to be placed must first be divided into five sections each way, thus producing twenty-five sections in all, as shown in Fig. 2 (*a*). In this illustration heavy dotted lines are used to separate the sections, and as certain of these lines coincide with the heavy lines of the design paper, the latter have been omitted. In practice, pencil lines may be used to divide the design paper into sections, as they may be made more quickly, and the only purpose is to divide the weave into imaginary sections. In Fig. 2 (*a*) certain of the sections, taken in 5-end satin order, have each been marked with a small square.

The next thing to be considered is the spot that will be placed on the design, as one must be selected that will not be so large as to interfere with other spots nor so small as to be obscure when the fabric is woven. It will be assumed that the spot shown in Fig. 2 (*b*) is to be used. The spots must be placed on the design paper in such a manner that they will be arranged in satin order, and be equally distant from each

other. By taking as a guide on which to build these spot figures the marked squares of Fig. 2 (*a*), which were placed on the sections in satin order, the desired result will be obtained.

It will be assumed that the squares marked in Fig. 2 (*a*) represent the topmost riser of the spot shown in Fig. 2 (*b*);

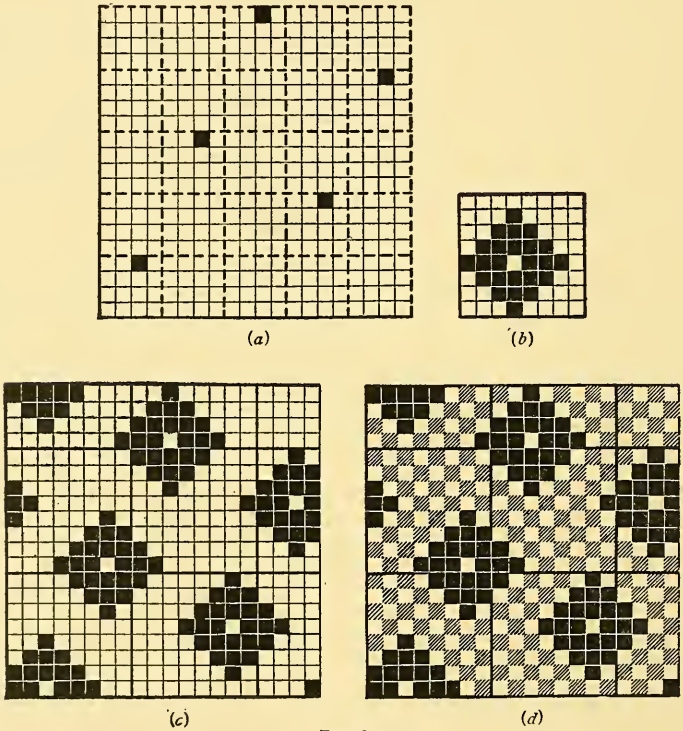
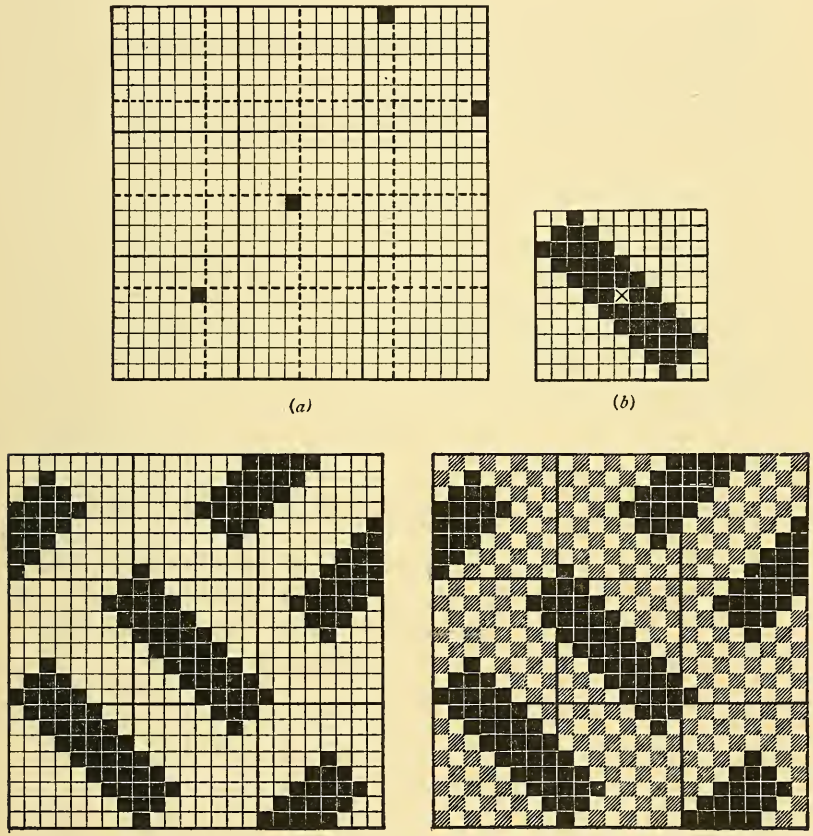


FIG. 2

then completing each spot, the 5-end satin arrangement of the spots shown in Fig. 2 (*c*) is obtained. The plain weave makes a very suitable ground weave for this design, and by inserting it properly, the completed design shown in Fig. 2 (*d*) is obtained.

5. As another example of spot-weave construction, suppose that it is desired to construct a spot weave on 24 ends and 24 picks, the spots to be arranged in broken crow order,

which will give four spots in each repeat of the weave. Fig. 3 (*a*) shows the design paper divided into sections after the manner previously explained. Small squares are also marked in certain sections, arranged in broken crow order, to indicate the positions of the spot figures. Fig. 3 (*b*)



(*a*) (*b*) (*c*) (*d*)

FIG. 3

shows the spot figure that is to be used, a small square in the center of the spot having been marked with a cross. It is intended that this square shall fall on the marked squares in Fig. 3 (*a*) when the spots are inserted in the design.

Fig. 3 (*c*) shows the spot inserted; two of the spots are twilled to the right and two to the left, for if all four of the spots were twilled in the same direction, two of the spots would necessarily run together, owing to their elongated shape. Fig. 3 (*d*) shows the completed design with the plain weave inserted as a ground weave.

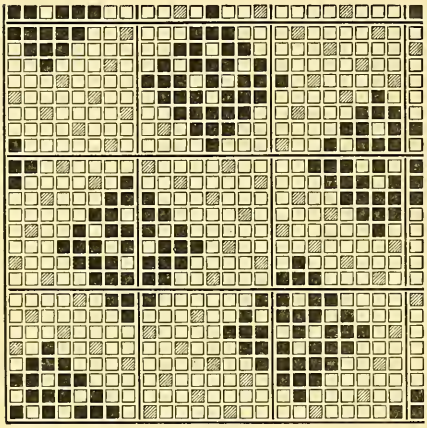


Fig. 4

6. Various weaves other than the plain weave may be used as ground weaves. Fig. 4 is given as an example of another type of ground weave. It is a spot weave on 25 ends and 25 picks, having the 5-end filling satin weave as a ground weave and with the spots arranged in 5-end satin order. In this design, wherever a riser of the ground would come in such a position as to interfere with the spot figure, that riser has been omitted. A plain ground could not be used in this design, because it would not match up well with every spot, and also because the weave repeats on an odd number of ends and picks.

FILLING-SPOT WEAVES

7. In constructing filling-spot weaves, the arrangement of the spots on the surface of the cloth is determined in exactly the same manner as described in connection with warp-spot weaves; in fact, the construction of a filling-spot weave very closely resembles that of a warp-spot weave with the single exception that in the former the filling floats on the surface of the cloth to form the spots, instead of the warp, as in the latter. To illustrate the construction of filling-spot weaves, suppose that it is desired to construct a spot weave

similar to that shown in Fig. 1 (*d*), with the exception that the spots are to be formed by the filling floating on the face of the cloth instead of the warp. In constructing this weave, wherever the spots are to appear on the cloth the warp must be depressed, so as to allow the spots to be formed by the filling floating, as shown in Fig. 5, and the spot is shown by blank squares instead of filled squares, as in the case of Fig. 1 (*d*), on this account. When inserting the ground weave in filling-spot designs, care should be taken to have the warp flushes of the ground weave oppose the filling flushes of the spot at every point so that the filling will not float over more ends than is desired to form the spots. In Fig. 5 the plain weave has been used as a ground weave and the risers of the ground weave completely encircle the filling flushes that form the spots.

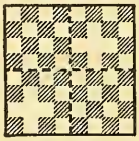


Fig. 5

As another illustration of the construction of spot weaves, suppose that it is desired to convert the warp-spot weave shown in Fig. 2 (*d*) into a filling-spot weave, retaining the same arrangement of the spots. Fig. 6 shows this weave complete, the spots being shown with blank squares, thus indicating that the warp is depressed and the filling raised, and therefore that the filling flushes form the spots on the face of the cloth. The plain weave has been used for a ground weave in this design, and the warp flushes of the ground weave oppose the filling flushes on all sides of the spots, as previously explained.

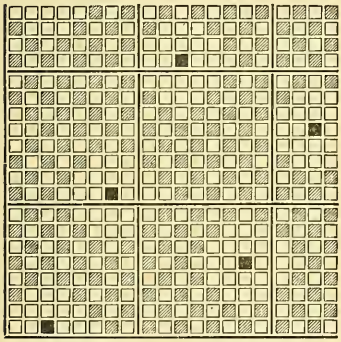


Fig. 6

8. Very neat effects may be formed in filling-spot weaves by using corkscrew or cord weaves as ground weaves, since both warp-corkscrew and warp-cord weaves show only warp on the face, or for that matter on the back of the cloth.

Filling spots may be made by allowing the filling to flush over a number of ends, and by having the warp of one color of yarn and the filling of another, a spot of a distinct color from the body of the cloth may be made; that is, the contrast between the color of the spot and the color of the ground is greater, because with warp corkscrews or cords as ground weaves the interlacings of the filling with the warp in the ground of the cloth do not show. Fig. 7 shows a weave constructed by this method in which a 7-end warp corkscrew has been used as a ground weave and the spots formed by flushing the filling on the surface of the cloth. In constructing weaves of this type, the best method of procedure is first to place the corkscrew or cord weave on the desired number of ends and picks, after which the spots may be made by erasing certain of the risers of the ground weave wherever it is desired to have a spot appear on the surface of the cloth. The number of risers that are erased will of course determine the extent of the individual spot. In constructing these weaves, it is very important that the warp flushes of corkscrew weave shall oppose the filling flushes on both sides of the spot. This has been done in Fig. 7; thus, considering the spot in the lower left-hand corner, on the eighth pick the third end is up and the fourth end down to form the spot, on the second end the filling that forms the spot flushes on the fifth, sixth, and seventh picks, while the warp flushes of the first end occur on these same picks. Again the filling flushes that

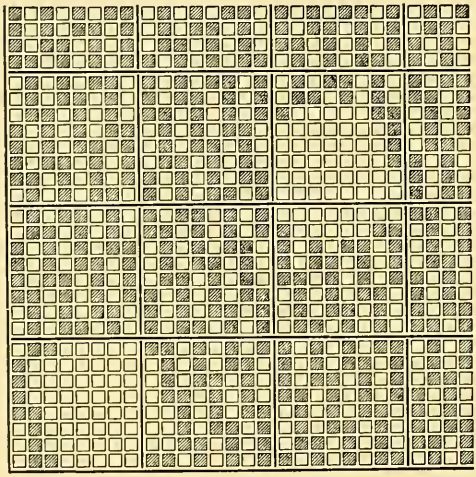


Fig. 7

form the spot cover the third end on the second, third, and fourth picks, while the second end is up on the same picks, etc. Warp-spot weaves may be made with corkscrew or cord weaves as ground weaves in a similar manner to filling-spot weaves. In this case, however, filling-corkscrew or filling-cord weaves are used as the ground weave and the spots produced by raising certain ends on as many picks as desired so as to form the spots.

EXAMPLES FOR PRACTICE

1. Make a warp-spot weave on 24 ends and 24 picks, using the plain weave as a ground weave and arranging the spot shown in Fig. 1 (*b*) in 8-end satin order.
2. Arrange the spot shown in Fig. 2 (*b*) in plain order on 18 ends and 18 picks and insert the plain weave as a ground weave.
3. Make an original warp-spot weave on 24 ends and 24 picks with the spot figures arranged in 6-end satin order.
4. Make a filling-spot weave on 28 ends and 28 picks, arranging the spots in plain order.
5. Arrange the spot shown in Fig. 3 (*b*) in plain order, twilling one spot to the right and the other to the left. Make the weave repeat on 16 ends and 16 picks and insert the plain weave as a ground weave.

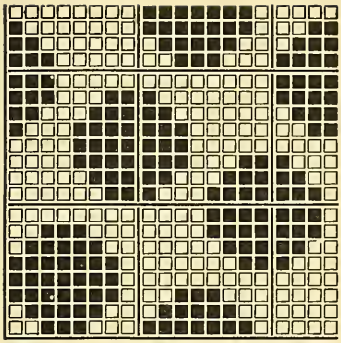
SPOT WEAVES FORMED WITH AN EXTRA SYSTEM OF YARN

SPOT EFFECTS WITH EXTRA WARP

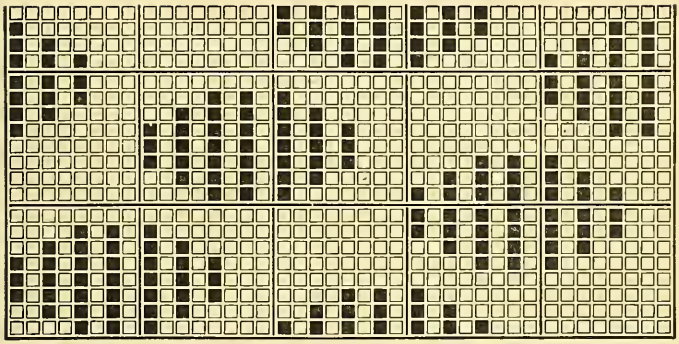
9. In many fabrics of a spotted character, the ground is woven with one warp and one filling, and the spots, which are generally of a different color from the ground, are produced by the use of an extra, or figuring, warp or filling, or both. In these cloths, the ground, or body, of the fabric is produced in the ordinary manner, while the extra system of yarn, either warp or filling, that produces the spot figures is allowed to float at the back of the cloth except at those places where the spots occur, where it floats on the face in such a manner as to produce a spot of the required shape and size.

10. Suppose that it is desired to construct a spotted fabric with the spots produced by an extra system of warp

yarn. In producing a design of this character, the first step is to decide on the spot figure that is to be used, and the arrangement of the spots on the surface of the cloth. Fig. 8 (*a*) shows a spot figure arranged in 5-end satin order, which, for the purpose of illustration, will be converted into an extra-warp spot design. It is constructed after the manner of the spot weaves previously described, except that the ground weave is omitted. The first step in arranging this spot for extra warp is to separate the ends of the spot design, as shown in Fig. 8 (*a*), by blank ends, as shown in Fig. 8 (*b*). That is, in Fig. 8 (*b*) each end of Fig. 8 (*a*) is copied, but is placed on an odd-numbered end of Fig. 8 (*b*), the even-numbered ends being left blank for the reception of the ground weave. The completed weave for an extra-warp fabric of this type will require twice as many ends and the same number of picks as the spot arrangement; that is, Fig. 8 (*a*) occupies 20 ends and 20 picks, while Fig. 8 (*b*) occupies 40 ends and 20 picks. The next step is to insert the ground weave, which forms the body of the cloth; in this case, the cassimere twill, Fig. 8 (*c*), will be used. The ground weave is inserted on the ends of Fig. 8 (*b*) that were left blank, or, in this case, the even-numbered ends, as shown in Fig. 8 (*d*), which is the completed design. If this weave is warped 1 end of white and 1 end of green throughout the warp, and a solid-green filling used, it will be seen that white spots arranged as in Fig. 8 (*a*) will be produced on the surface of a solid-green twilled fabric. The extra, or white, warp floats on the face only to form the spot, and when not producing the spot is carried to the back of the fabric. The green, or body, warp, however, is interlaced with the filling as a cassimere twill to form the ground fabric on which the white spots are arranged. Since the extra, or figuring, warp interlaces so infrequently with the filling, it takes no part in forming the structure, or body, of the cloth; the ground ends, being crowded together by the interlacing of the filling, throw the extra-warp ends up on the face to form the spot when these ends are raised and force them to the back when they are depressed. Care



(*a*)



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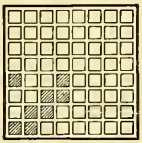
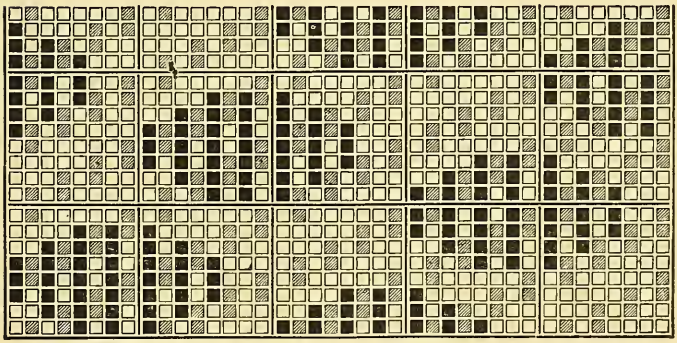


(*c*)



(*d*)

FIG. 8.

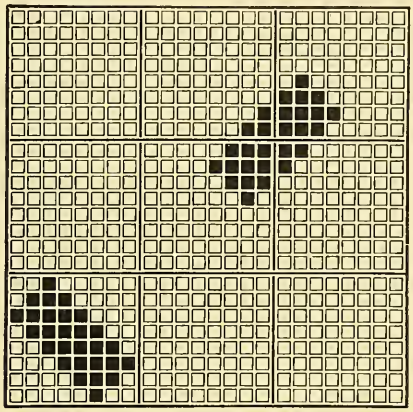
must be taken in selecting a ground weave for these fabrics to select a weave that will repeat evenly on the number of ends and picks that is occupied by the spot arrangement; that is, it must repeat evenly on the same number of picks and one-half the number of ends that the completed weave occupies.

11. Tying.—It frequently happens in the case of very thin fabrics that the extra warp when carried to the back of the fabric will show through on the face, especially if the ground cloth is of a light color and the figuring warp dark, or vice versa. When this is the case, the loose floats of the extra warp must be cut from the back of the fabric, but if this is done, the weave must be arranged so that the spots will be firmly bound to the cloth. In the case of Fig. 8 (*d*), if the floats of the extra warp on the back of the cloth were cut off close, there would be nothing to attach the face floats of extra warp to the cloth, since the extra warp is only passed from the face to the back without other interlacing with the filling. Therefore, such a fabric would not be serviceable, since the spots would easily rub and wear off. To remedy this fault, it is customary, when the figuring warp is to be cut from the back of the cloth, to bind each float of the extra warp on the face by passing it under 1 pick and over 1 pick of the ground before passing it finally to the back of the cloth. This extra binding at the edge of the spots prevents the floats of the extra warp on the face from being too easily rubbed off after the floats at the back of the cloth have been cut and removed.

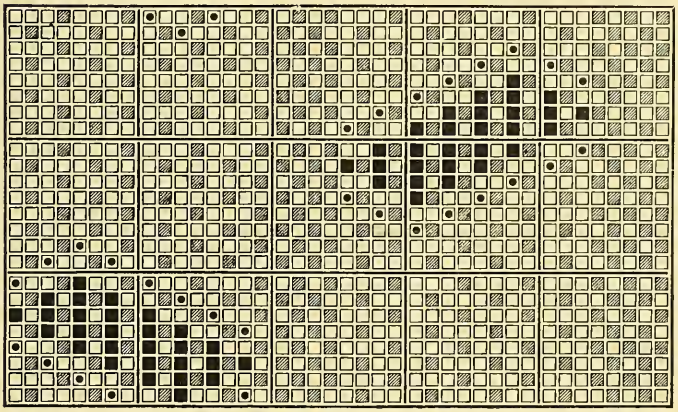
Fig. 9 (*a*) shows an arrangement of spot figures in plain order, while Fig. 9 (*b*) shows these spots arranged as an extra-warp design with each face float of the extra warp bound to the cloth by passing it under and over the filling before finally allowing it to float on the back of the fabric. The ground weave in this case is the plain weave.

In some cases it is not desired to cut the extra-warp floats from the back of the cloth, and yet the spots are so far apart on the face that the floats on the back are so long as to be very loose. When this is the case, the extra warp is usually

tied to the ground cloth by being raised over a single pick of the ground weave at a point approximately half way between the spots, that is, in the center of the float on the back, or perhaps the float may be tied twice or even oftener between



(*a*)



(*b*)

FIG. 9

the spots. In arranging these tying places, care should be taken to bring the extra warp up on a pick that has a ground-warp end on each side also raised over it. These floats of the ground ends will then crowd together and completely

hide the tying place of the extra warp. To illustrate this point, Fig. 10 (*a*) shows an elliptical spot arranged in plain order, while Fig. 10 (*b*) shows the same design arranged for extra warp, with the extra warp tied into the cloth. Particular attention should be paid to the position of the tying

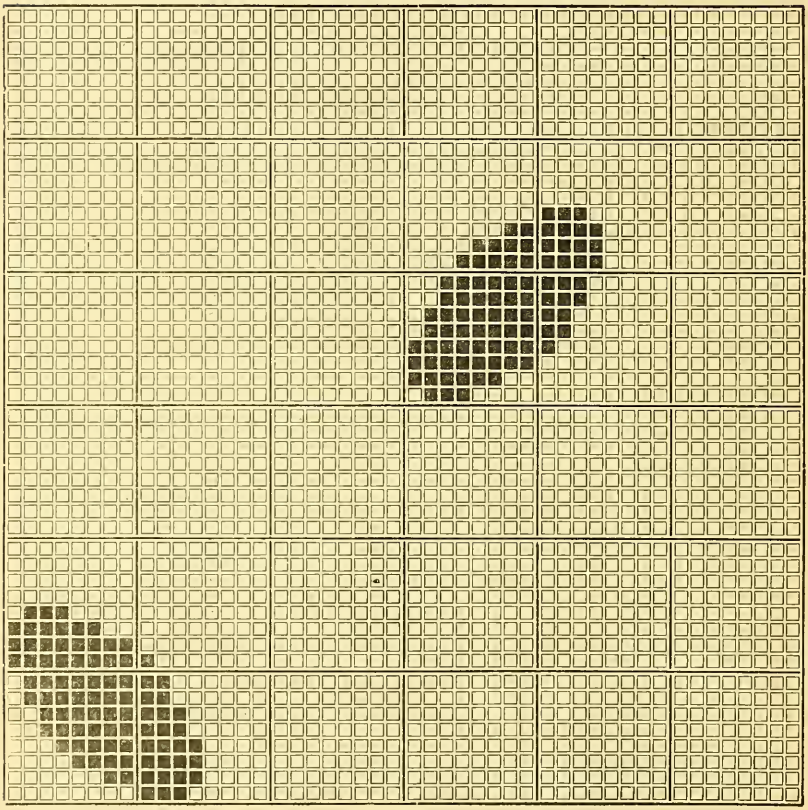


Fig. 10 (*a*)

places, since the extra warp is raised in each instance between two warp floats of the ground weave and as near the center of the extra-warp float on the back of the cloth as is consistent with the attainment of proper binding places for concealing the extra-warp end.

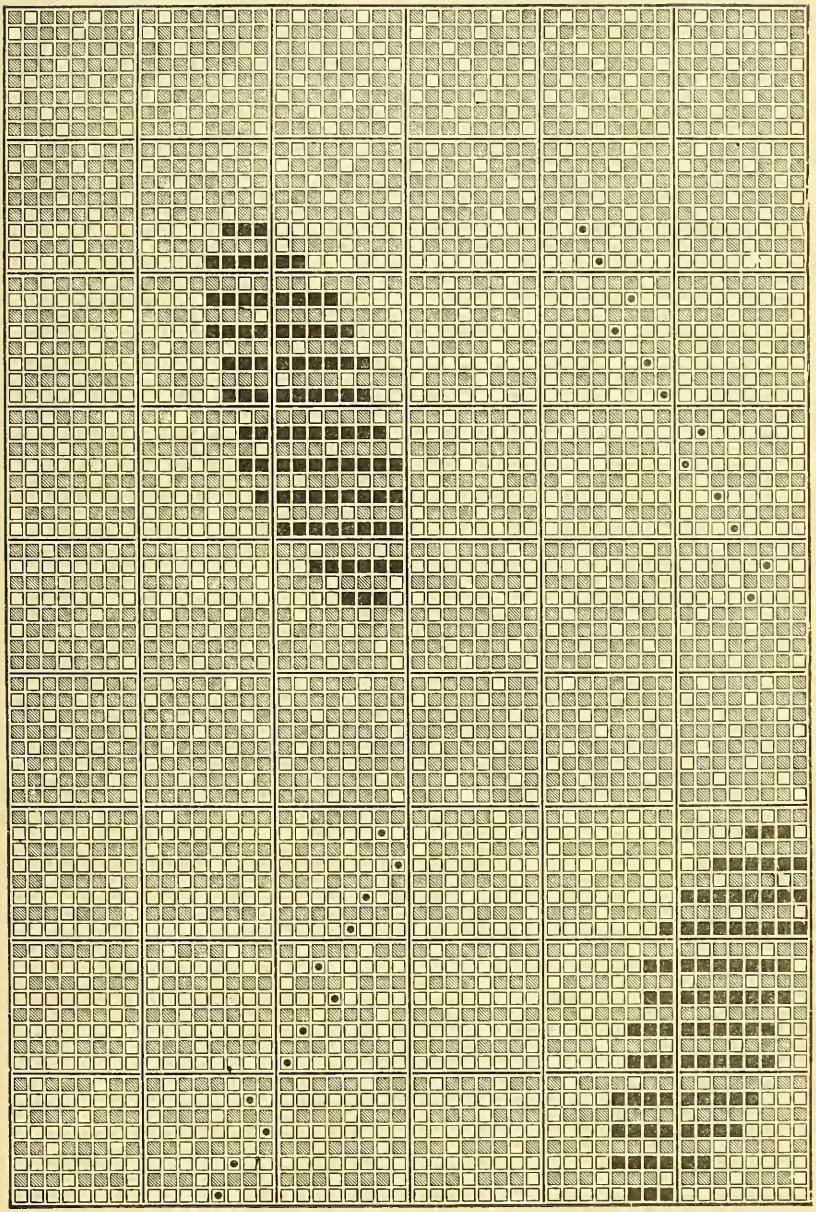


FIG. 10 (b)

12. Stripe Spot Effects.—When it is desired to separate the spots so that they will appear on the surface of the cloth a greater distance apart, as many ends of the ground weave as are desired may be inserted between the spots. Spots are often arranged one above the other in the direction of the warp and a large number of ground ends inserted between them, thus forming a cloth having a **spot stripe** running through it. Fig. 11 shows a design of this description, a simple round spot being arranged so that as the design repeats in the cloth, the spots will be repeated one over the other throughout the length of the cloth. The ground weave is the 4-harness basket and is repeated so that the spotted stripes down the length of the cloth will be separated by 43 ends of the ground. This separation of the stripes can of course be increased or diminished to suit any requirements, by simply inserting the required number of repeats of the ground weave. If this weave were woven with a warp

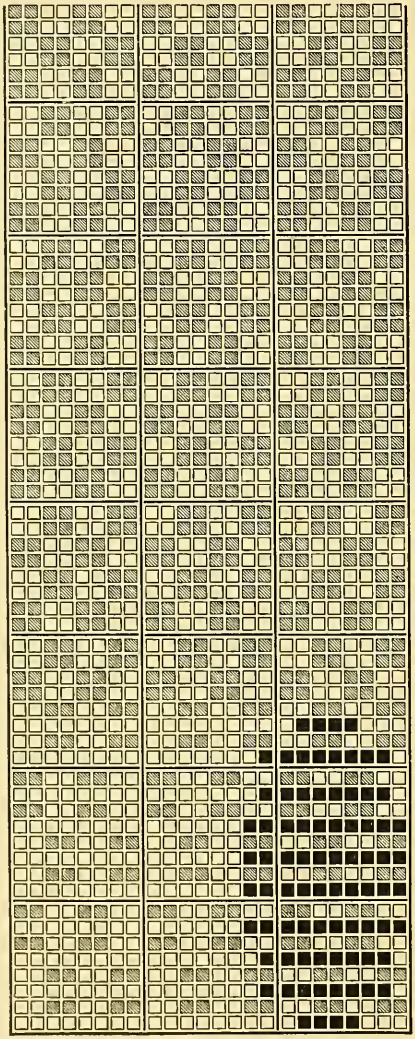


Fig. 11

arranged 1 end of black and 1 end of red for 20 ends and then 42 ends of red, and a solid-red filling used, a stripe of black spots would be formed on a red ground.

Stripe spot effects are often arranged so that spots of two or more different colors are formed, often alternately one above the other. When this is the case, 2 extra-warp ends must be inserted together between the ground ends; that is, if two differently colored spots are to be formed. Fig. 12 shows a design arranged in this manner. If the warp were arranged 1 black, 1 white, 1 red, for 18 ends, 1 black, 1 white, 80 red, and woven with red filling, a red fabric would be formed with a stripe composed of alternate spots of black and white. The lower spot in Fig. 12 would form a black spot and the upper one a white spot.

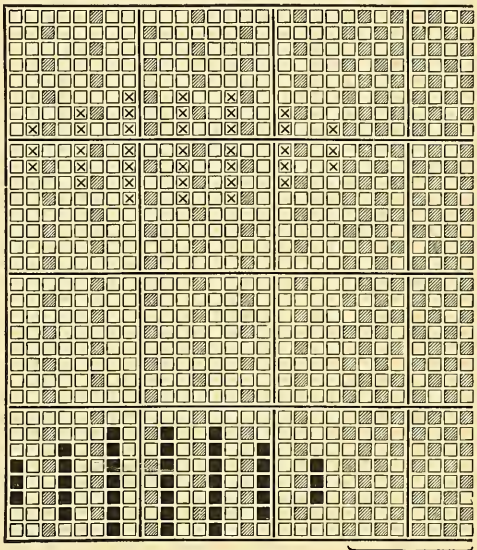
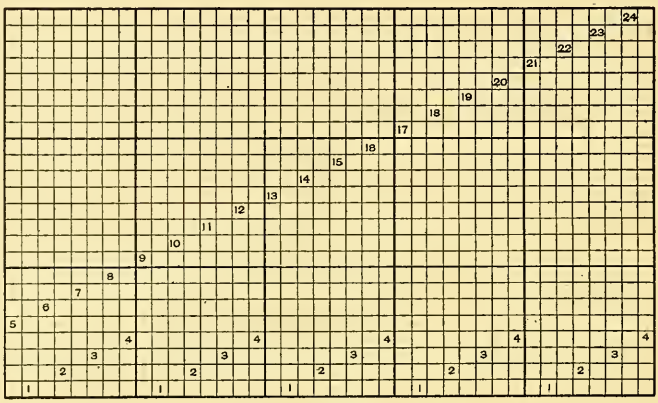


Fig. 12

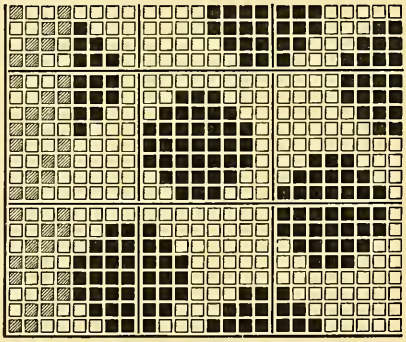
10×

13. Harness and Chain Drafts. In making harness, or drawing-in, and chain drafts for extra-warp fabrics, it is advisable to separate the harnesses carrying the ground ends from those carrying the extra-warp ends, since fabrics of this description require two beams, owing to the difference in take-up between the ground warp and the extra, or figuring, warp. It is customary to draw the ground ends on the front harnesses and the extra-warp ends on the back harnesses, although this is a matter of very little importance. The design could just as well be woven with the extra warp

drawn on the front harnesses as with the ground warp drawn on the front harnesses, but the latter is a little more convenient, since the ground warp in many cases contains a greater number of ends than the figuring warp; consequently there is a greater liability of the ground ends breaking, and



(*a*)



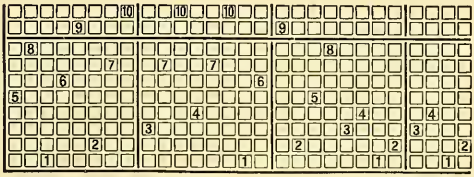
(*b*)

FIG. 13

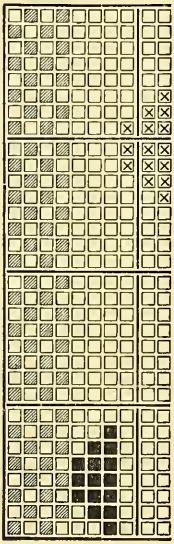
if drawn on the front harnesses, it is very much easier to tie ends in when they break in the loom. Fig. 13 (*a*) shows the drawing-in draft for the design shown in Fig. 8 (*d*), while Fig. 13 (*b*) shows the corresponding chain draft. From a careful study of these drafts, their method of construction

will be readily apparent and no further explanation will be necessary.

As another illustration, however, using a somewhat different case, Fig. 14 (*a*) and (*b*) is given. Fig. 14 (*a*) is the drawing-in draft, and Fig. 14 (*b*) the chain draft for Fig. 12. There are two distinct systems of extra warp; the ground



(*a*) 10×



(*b*)

FIG. 14

ends have been drawn on the first 4 harnesses, the black extra warp on the second set of 3 harnesses, that is, on the fifth, sixth, and seventh harnesses, and the white extra warp on the eighth, ninth, and tenth harnesses. By separating the warp into three systems in this manner, the first

4 harnesses will carry red ends only, while the fifth, sixth, and seventh will carry only black ends, and the eighth, ninth, and tenth only white. This makes it much easier for the weaver when tying in broken ends than would be the case if the black and the red extra-warp ends were drawn in on alternate harnesses, as they appear in the design; that is, this design could be drawn in so that the first 4 harnesses would contain the ground ends; the fifth harness, black extra-warp; the sixth harness, white extra-warp; the seventh harness, black extra-warp; the eighth, white extra-warp; the ninth, black extra-warp; and the tenth, white extra-warp. If this method were used, there would be some liability of the weaver drawing the extra-warp ends through the wrong harnesses when tying in broken ends. A careful comparison of Fig. 14 (*a*) and (*b*) and Fig. 12 will show distinctly the method of constructing the harness and chain drafts.

EXAMPLES FOR PRACTICE

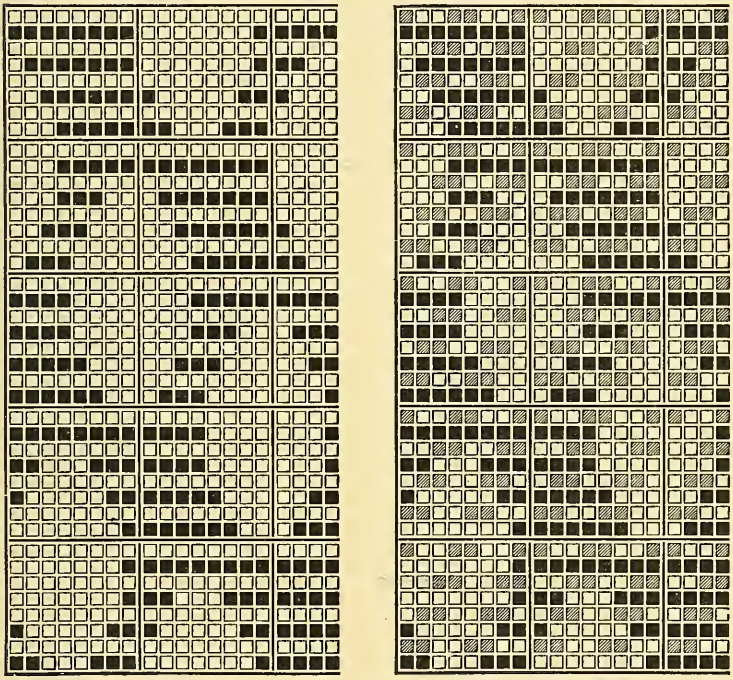
1. Arrange Fig. 3 (*c*) as an extra-warp spot design, using the plain weave as a ground weave.
2. Show harness and chain drafts for the design made in answer to example 1, showing the ground ends drawn on the 4 front harnesses.
3. Arrange Fig. 2 (*c*) as an extra-warp spot design, using the 4-harness cassimere twill for a ground weave.
4. Show harness and chain drafts for the design made in answer to example 3.
5. Show harness and chain drafts for Fig. 11, drawing the ground weave on 4 harnesses.

SPOTS FORMED BY EXTRA FILLING

14. Cloths in which the spot is formed on the surface by an extra, or figuring, series of filling yarn are constructed very similar to extra-warp fabrics, except that the spots are produced by filling yarn instead of warp yarn. The structure of the fabric may be said to be practically the same; that is, the cloth consists of a ground, or body, woven with a simple weave, and spots produced by flushes of extra filling on the face at certain points, while when the figuring filling is not to be used to form a spot, it floats on the back of the

cloth. In constructing fabrics of this kind, place the spot figures on the design paper, alternating each pick with a blank pick, on which the ground weave may afterwards be inserted.

After deciding on a certain spot and arrangement of spots, the spots must be so placed on the design that the filling will flush on the face at those points where it is desired to have



(*a*) (*b*)

FIG. 15

the spots appear. For instance, suppose that it is desired to arrange Fig. 8 (*a*) for an extra-filling design. Separate the picks and place them on design paper, as shown in Fig. 15 (*a*); wherever it is desired to have the spot appear, the filling is allowed to flush on the face, and at every other place the entire warp is raised over the pick of filling so that it will float on the back of the cloth. Fig. 15 (*a*) represents the

exact reverse of Fig. 8 (*a*), with the exception, of course, that Fig. 15 (*a*) is opened out, the picks being separated by blank picks. To complete the design it is now only necessary to insert the ground weave on the blank picks that are left for its reception. The completed design is shown in Fig. 15 (*b*), in which the 4-harness, or cassimere, twill has been inserted as a ground weave. While with extra-warp fabrics twice as many ends as picks were required, in extra-filling fabrics twice as many picks as ends are required, that is, if the spots are not separated by several picks of ground.

15. To illustrate further the method of forming designs of this type, suppose that it is desired to arrange the spot shown in Fig. 16 (*a*) as an extra-filling design. Fig. 16 (*b*) shows this spot arrangement placed on the design paper occupying 18 ends and 36 picks; that is, Fig. 16 (*b*) occupies the same number of ends and twice as many picks as Fig. 16 (*a*). Inserting a plain ground weave, as shown in Fig. 16 (*c*), completes the design, which will produce a spot arranged in plain order. If either Fig. 15 (*b*) or Fig. 16 (*c*) is woven with a solid-red warp, and picked 1 white and 1 red, white spots will be produced on a red fabric, and in the case of Fig. 15 (*b*), the arrangement, shape, and size of the spots will be exactly the same as in Fig. 8 (*d*), except that the spots in Fig. 15 (*b*) will be formed with an extra-filling yarn, while in Fig. 8 (*d*) they are formed with extra-warp yarn.

16. Tying.—In cases where the extra-filling yarn is to be cut from the back of the cloth, each float of extra filling on the face of the cloth may be bound in a manner similar to that explained in connection with extra-warp fabrics. This is accomplished by allowing the filling to be depressed under 1 end and float over 1 end at each end of each filling float on the face, thus tying the fabric in the same manner as the extra warp was tied. Also, if the floats of filling on the back of the cloth are not cut off and are very long, it is well to tie the extra filling to the body of the cloth. This may be accomplished by raising the pick of filling over a single end at a point somewhere near the middle of the float on

the back, arranging this tying place so that the extra filling will be raised over an end between two picks of the ground filling that are raised over the same end. These two filling

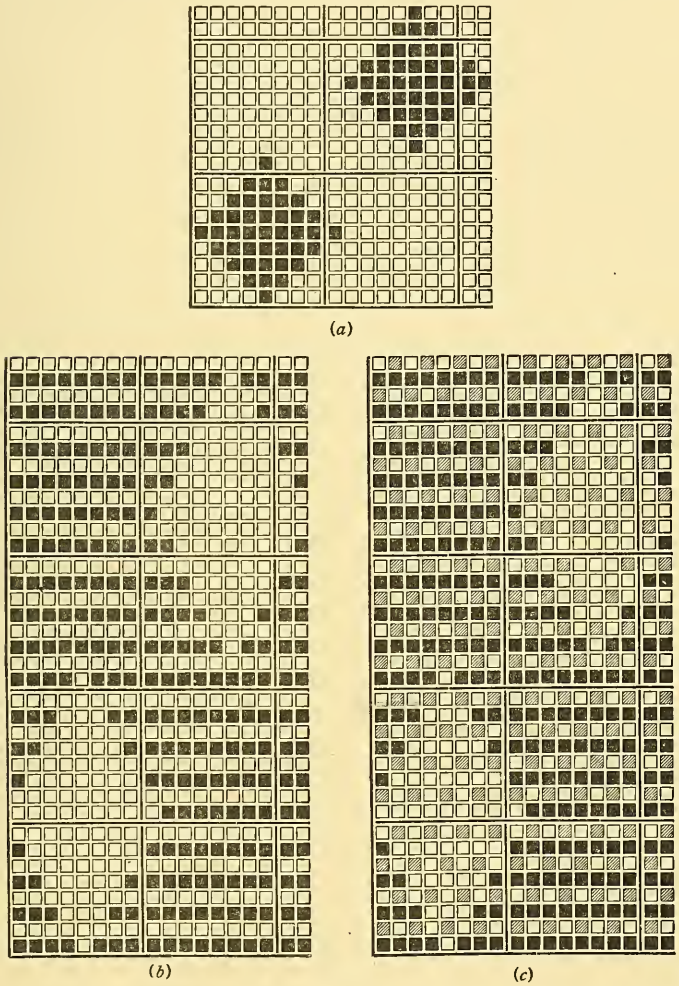


FIG. 16

flushes of the ground will cover the tying place so that it cannot be seen on the face of the cloth.

17. In arranging the harness and chain drafts for extra-filling fabrics, no difficulty should be experienced, since the fabrics are woven with a single system of warp and drawn in exactly like a simple fabric, usually being arranged as a straight draft.

EXAMPLES FOR PRACTICE

1. Arrange Fig. 3 (*c*) as an extra-filling design, using the plain weave for the ground.
2. Arrange Fig. 9 (*a*) as an extra-filling design, using the cassimere twill for the ground weave.
3. Arrange Fig. 10 (*a*) as an extra-filling design, using the 4-harness basket weave for the ground.
4. Make an original spot figure and arrange it in 6-end satin order as an extra-filling design to be complete on 30 ends and 60 picks.
5. Show harness draft for the design made in answer to example 3.

WEAVES FOR BACKED COTTON FABRICS

Serial 510 Edition 1

FILLING-BACKED CLOTHS

1. In many cloths, an extra system of warp or filling is adopted for the purpose of adding weight, bulk, or warmth, in which case the extra yarns are bound to the cloth at regular intervals in such a manner that they do not show at all on the face. Cloths of this description are known as **backed fabrics.** The manufacture of backed cloths is often resorted to for the purpose of making a heavy and yet cheap fabric, since by using a cheaper extra warp or filling a thicker and more substantial cloth can be obtained at a low cost, while at the same time the necessary thickness and weight may be obtained without altering the fineness of the face of the fabric or without changing its appearance.

2. Under the head of backed fabrics are found two subdivisions; namely, cloths backed with *filling* and cloths backed with *warp*. A **filling-backed fabric** may be considered as a single cloth consisting of one warp and one filling, but having bound, or tied, to the back an extra set of filling threads, which are interlaced with the face cloth just enough to keep them attached and prevent the floats on the back of the cloth from being so long that they will be loose. This effect is obtained by raising the warp yarn in such a manner that when the face, or regular, filling is inserted it will interlace with the warp and form the pattern desired.

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When, however, the pick of backing filling is placed in the cloth, all the warp ends are raised with the exception of a few that are left down, in order to bind the backing filling to the face cloth. This has the effect of making the picks of backing filling float on the back of the cloth, except where they pass over the few ends that accomplish the *binding*, *tying*, or *stitching*, as it is sometimes called.

The filling in filling-backed fabrics may be arranged 1 pick of face and 1 pick of back, 2 picks of face and 1 pick of back, or 2 picks of face and 2 picks of back. All filling-backed fabrics, since they are composed of two different fillings, require a box loom for their production, unless the same yarn is used for the backing filling as for the face, which is not usually the case. In case the cloth is woven in a loom that has but one box on one of its sides, the filling must be inserted 2 picks of face and 2 picks of back, since in this type of loom it is not possible to put in a single pick of one kind of filling, as the shuttles must always return to the box side before changing. Fabrics in which a single pick of the backing filling is inserted at a time require a loom with more than one box at each side, in which it is possible to change the filling at either side of the loom and consequently on any pick. When, as is often the case, coarser yarns are used for the back than for the face filling, the fabric is often woven with 1 pick of backing and 2 picks of face, and sometimes in extreme cases, 3 or even 4 face picks are used to 1 pick of backing.

Weaves for filling-backed cloths woven with face and backing filling in the proportions given are not always arranged in exactly the order stated. For instance, the weave for a cloth woven with 2 picks of face alternating with 1 pick of backing may be arranged 1 face, 1 back, 1 face. This, of course, makes no actual difference in the cloth and is simply mentioned so that if a weave is noticed in which the first pick is a face pick and the next pick a backing pick, it will not be thought that the weave is necessarily arranged 1 face and 1 back, since the next 2 picks may be face picks, and so on.

3. When binding the backing filling to a filling-backed cloth, the tying places should be so arranged that the backing picks will be over the face-warp ends between two floats of the face filling. The object of this is to cover the tying places so that they cannot be seen on the face of the cloth, the two floats of the face filling, one float on each side of the backing filling, crowding over the backing pick where it passes over the warp and thus hiding it from view.

In addition to so tying the backing filling that it will not show on the face of the cloth, the tying places should be placed uniformly throughout the fabric so that the cloth will not cockle. The best method of distributing the tying places is in satin order, since by this method not only are they evenly distributed, but all liability of the binding places forming twill lines on the face of the cloth is obviated. Although the method of distributing the tying places in satin order is the most satisfactory, because of the scattered yet uniform disposition of the interlacings of the back filling with the face warp, it often happens that the character of the face weave is such that the tying places cannot be distributed in this manner and at the same time each be located between two flushes of the face filling. When such is the case it is always better to adopt some other system of binding, such as twill, broken crow, etc., rather than run the risk of having the backing yarn show on the face of the goods. With filling-backed fabrics, it is impossible to form any fancy effects on the back of the fabric, and, in fact, this is not desired, since the main object is to obtain a heavy- or medium-weight fabric with a fine face produced with yarns of fairly high counts.

4. When making designs for filling-backed fabrics, the first step is to indicate the face and back picks on the design paper, in order that they may not be mistaken and the weave placed on the wrong pick. This may be accomplished by placing a small mark at one side of the design opposite each backing pick or, preferably, by shading the backing picks with a colored pencil. If the design is to be composed of

1 pick of face alternating with 1 pick of back it is better to start at the bottom of the design and make the first pick a face pick. The second pick should be made a back pick, by shading, and so on until the required number of picks have been treated in this manner.

5. Suppose that it is desired to back the 8-harness twilled basket weave shown in Fig. 1 with filling, in order to obtain a heavier fabric, the filling to be inserted 1 pick back, 2 picks face. This will give 4 picks of back and 8 picks of face, or 12 picks altogether, in 1 repeat of the design. When making a filling-backed design of any description, care must be taken to have both the back and face weaves evenly repeated on the back and face picks, respectively. The method of backing must also be considered when determining the size of the completed design. The first operation is to indicate the backing picks, which may be done by shading them, as shown in Fig. 2. The face weave, Fig. 1, is then placed on the face picks in Fig. 2, as indicated in Fig. 3, the backing picks still remaining unmarked.

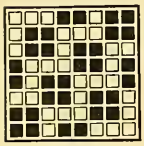

Fig. 1

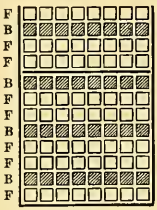

Fig. 2

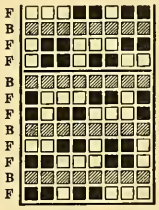

Fig. 3

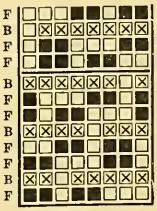

Fig. 4

The next step in the formation of the design is to raise all the warp on the backing picks, except such threads as are required to be left down for the purpose of binding the backing filling to the body of the cloth. The method of doing this is shown in Fig. 4, the squares marked with crosses indicating where the warp is raised over the backing picks. By referring to this design, it will be noticed that the tying points are distributed in twill order, as this is the best method by which the filling can be bound with this weave, it being obviously impossible to use satin order of tying without repeating the design,

since there are only 4 picks of backing filling. It will be noticed that the binding places, where the backing filling comes to the face of the cloth, are placed on ends over which the face filling passes on the preceding and succeeding pick, thus hiding the pick of backing filling. Thus, for example, on the first and third picks, which are face picks, the filling passes over the same end as does the backing filling on the second pick. This method of raising the picks of backing filling occurs throughout the weave. Each pick of backing filling in this design is tied to the face only once in 8 ends, but it would be possible with this design to bind the backing filling twice in 8 ends, if it were desired to produce a firmer piece of goods.

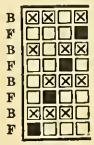

Fig. 5

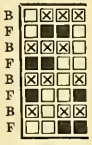

Fig. 6

6. Fig. 5 shows a filling-backed design arranged 1 face and 1 back. In this design, every end of the warp serves at one time in each repeat of the weave to bind the backing filling to the face. Tying on every end of the warp in filling-backed fabrics makes the most perfect cloth, since all the ends will then take up the same and there will be no liability of the cloth wrinkling. However, this is not always done, especially when a soft cloth is desired. Very often every other end of the warp serves to tie the backing filling, as is the case in Fig. 4. It is not best, however, to tie on every other warp end if a very thick or coarse backing yarn is to be used, since this will surely make a faulty cloth unless two warp beams are used, which is rarely done with a filling backed fabric. When designing filling-backed cloths, it is always best to use soft-twisted yarn for the backing; hard-twisted or too coarse backing yarn is more or less liable to show on the face of the cloth, especially if fine yarns are used for the face weave.

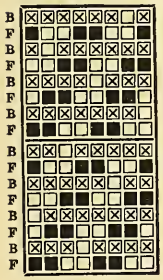

Fig. 7

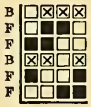

Fig. 8

The cassimere twill $\frac{2}{2}$ is a weave that is often required to be backed with filling, and in Figs. 6, 7, 8, and 9, four standard methods of accomplishing this are shown. The designs in Figs. 6 and 7 are to be preferred, as the backing filling is tied an equal number of times on each end of the warp. Figs. 8 and 9, while not tied perfectly, may be successfully used in cases where the backing filling is not too coarse.

7. In constructing weaves for filling-backed cloths, the best relation of the face weave to the back weave should always be determined. For instance, suppose that a face weave is placed on design paper as shown in Fig. 10. In this case, there is no place where the backing pick can be raised for tying without having the face warp up on one side of the

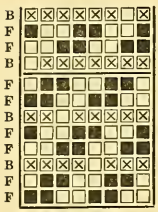

Fig. 9

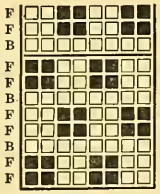

Fig. 10

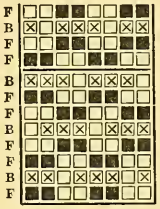

Fig. 11

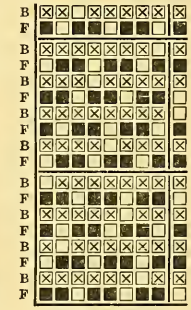

Fig. 12

tying point, which is liable to cause the binding to show on the face of the goods. If, however, the face weave is placed on the design paper as shown in Fig. 11, the backing can readily be tied to the face without any danger of its showing. The backing weave in this design is the broken crow weave.

Weaves that have a large percentage of warp on the face, especially warp-flush twills, are the hardest to back with filling, on account of there not being places in the weave where the tying places may be perfectly covered. When such weaves are backed with filling and it is impossible to have a face-filling flush on each side of the tying place, the design should be so arranged that the flush of face filling next to the tying place shall follow rather than precede the flush of backing filling. When the face flush precedes the

backing flush, the tie will show prominently on the face of the goods; but when the face flush follows the backing flush, the reed, in beating up the filling, will push the face pick over the backing pick. This method is employed in the weave shown in Fig. 12, where the warp-flush prunelle twill has been backed with filling, the backing weave being the 9-end satin weave.

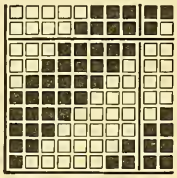

Fig. 13

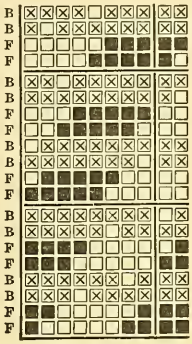

Fig. 14

8. In Fig. 13 a 10-harness regular twill $\frac{5}{5}$ is shown, while in Fig. 14 the same twill is shown backed with filling arranged 2 face and 2 back. Particular notice should be taken of the arrangement of the tying places in this design, as well as those in Fig. 15, which represents two repeats of the same twill backed with filling and arranged 2 face and 1 back. In Fig. 15, the backing filling is tied on every other end by two lines of twills, thus tying on all the ends in the warp.

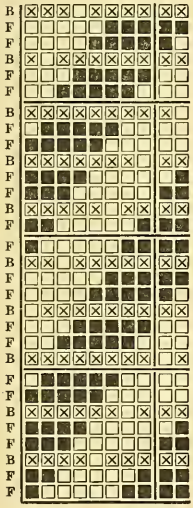

Fig. 15

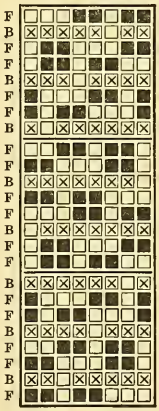

Fig. 16

In order to obtain a good system of tying, it is often necessary to repeat a design. Thus, for instance, if it was desired to use heavy or coarse backing filling in the design shown in Fig. 4, it would be necessary, in order to tie on every end to either bind the filling once in every 4 warp ends or repeat the design and bind as shown in Fig. 16, which shows Fig. 4 repeated in its picks.

When tying a backing filling to a face cloth that has long filling floats, the tying places should always be as near the center of these floats as possible, since, when tied in this manner, the binding points will be more easily covered.

EXAMPLES FOR PRACTICE

1. Make a filling-backed weave arranged 1 face, 1 back, using the $\frac{4}{4}$ regular twill for the face; tie the backing filling perfectly once on each warp end.

2. Make an 8-end filling satin and back it with filling, arranging it 1 face and 1 back.

3. Back the cassimere twill with filling, the weave to be arranged 1 face and 1 back and capable of being woven on 4 harnesses.

4. If a 12-harness regular twill is backed with filling, the weave being arranged 1 face, 1 back, 1 face, on how many ends and picks will the weave be complete?

5. Back the regular twill $\frac{2}{2}\frac{2}{2}\frac{1}{1}$ with filling, arranging the weave 1 face and 1 back. Tie each backing pick once in 10 warp ends.

6. Back the $\frac{3}{1}$ twill, twilled to the left, with the 8-end satin, arranging the weave 1 face and 1 back; have the face-filling flush follow rather than precede the back-filling flush.

WARP-BACKED CLOTHS

9. Warp-backed fabrics are those cloths constructed with one system of filling and one system of warp yarns for forming the face of the goods and also an extra system of warp yarn for making a heavier and warmer fabric than would be possible with a single cloth. These cloths require more harnesses than filling-backed cloths, on account of the extra, or backing, warp, while on the other hand they can be woven in looms with single boxes, since there is only one system of filling to be placed in the cloth. This is a great advantage in those cases where single-box looms are all that can be used. This of course applies only to cloths in which one kind or color of face filling is used, since if more than one kind is used a box loom will be necessary.

It requires only the same amount of time to weave warp-backed fabrics that would be occupied in weaving any cloth with the same number of picks per inch, since there are no extra picks of backing filling to be placed in them. Color can also be applied to the back of warp-backed fabrics to advantage, since stripe effects can be easily made, while with filling-backed cloths only bars across the cloth can be made, which is rarely a satisfactory method of applying color. However, care should be taken in all cases where a different color from that of the face yarn is applied to backed cloths, to have the binding points perfect, so that the color of the backing yarn will not show on the face of the goods.

In weaving the majority of cloths backed with warp two beams are required, since the backing warp is generally of a coarser yarn and has different interlacings with the filling than has the face warp, thus causing a different amount of contraction. It is necessary that the backing yarn in a warp-backed fabric should be harder-twisted than the backing yarn in a filling-backed fabric, since it has to withstand the strain that comes on all warp yarn during weaving. On this account warp-backed fabrics will feel harsher and stiffer than filling-backed fabrics, in which soft-twisted yarns are almost exclusively used for the backing filling.

10. There are several important points that should be noted when considering warp-backed fabrics. (1) The backing-warp must be raised over a pick in every instance where it is desired to bind the backing warp to the face cloth; this, it will be seen, is the reverse of the case with filling-backed fabrics, where a warp end is depressed, in order to bind the cloth. (2) In warp-backed fabrics, the tying places should always be placed between two warp flushes of the face cloth, in order that the tying may be covered and not show on the face of the cloth; if in any case this is impossible, the backing warp may be raised either to the right or left of a face-warp flush. (3) If there are more interlacings of the face warp with the filling than there are of the back warp with the filling in a given number of

picks, or if one series of warp yarn is coarser than the other, it will be necessary to place the two warps on separate beams, since the take-up of the warps in weaving will be different. (4) It is always best to select weaves of regular structure, such as satins, broken crow, etc., for the backing weave, so that each backing end will have the same number of interlacings. (5) If a warp-backed fabric is arranged 1 face and 1 back, the backing warp should never be of heavier yarn than the face, since if this is the case the back will show through on the face of the cloth. (6) If the design is arranged 2 face and 1 back, a proportionately heavier yarn can be used for the back warp.

11. Suppose that it is desired to back the cassimere twill with warp, using the 8-harness satin weave for binding the backing warp to the cloth, the design to be arranged 1 face end and 1 back. As the back weave in this case will require 8 ends, it will be necessary to show two repeats of the face weave in the complete design, the cloth being woven 1 and 1. Therefore, the finished design will be complete on 16 ends and 8 picks. The first operation is to shade or in some other manner to indicate the backing ends, in order that

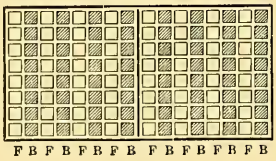

Fig. 17

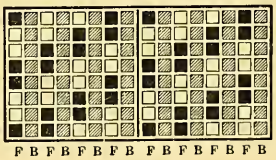

Fig. 18

they may be distinguished from the face ends. The method of doing this is shown in Fig. 17, where the vertical rows of squares for the backing weave are shaded, while those for the face weave are left blank. Fig. 18 shows the cassimere weave, which is to be used for the face weave in this design, placed on the face ends. The next step is to place the backing weave on the design. As the back weave, which is to be the 8-end satin, must flush on the back of the cloth, each back-warp end should be raised only once in 8 picks and in

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satin order. The method of placing the back weave on the design paper is shown in Fig. 19, where the design is shown complete, crosses indicating where the backing warp is raised. In this figure, the method of raising the back warp at the

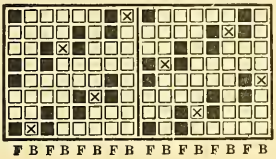


Fig. 19

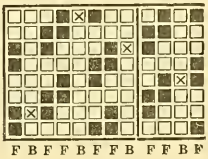


Fig. 20

tying places between two face-warp flushes should be carefully noted, the object of course being to allow the floats of face warp to crowd over and hide the tie.

12. Fig. 20 is another design showing the cassimere twill backed with warp. In this case, however, the ends are arranged 2 face and 1 back and the back warp is bound in left twill order. Fig. 21 shows still another method of back-

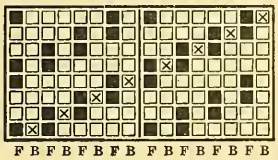


Fig. 21

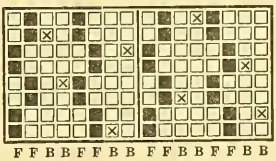


Fig. 22

ing the cassimere twill with warp, each backing warp end being tied once in 8 picks and the ends arranged 1 face and 1 back. Fig. 22 is a design for a basket weave backed with the 8-end satin weave, the ends being arranged 2 face and 2 back.

HARNESS AND CHAIN DRAFTS

13. Ordinarily, with filling-backed fabrics, only as many harnesses are required to weave the design as are required for the face weave alone. In the case of warp-backed fabrics, however, as the backing warp always interlaces with the filling differently from the face warp, it must be drawn in

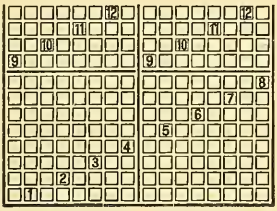
on separate harnesses. A warp-backed weave may be drawn in exactly as a single cloth if it is so desired. In this case, if the weave is arranged 1 face and 1 back, the first harness will be used for the face warp, the second harness will have the backing warp, and so on, each alternate harness being used for the backing harness. This method of drafting is adopted in some instances in connection with warp-backed fabrics of simple design, but in the majority of cases it is desirable to separate the harnesses for the backing warp from those through which the face warp is drawn, since it makes the harness draft much simpler for the weaver, thus rendering the liability of broken back-warp ends being tied in on harnesses through which face ends should be drawn, or vice versa, less probable.

There are two methods of separating the harnesses carrying the backing warp from those carrying the face, the first being that of drawing in the back warp on the back harnesses and the second being that of drawing the back warp through the front harnesses. Both methods are largely in use, but for certain reasons the latter is to be preferred. By drawing the backing ends through the front harnesses they are more readily accessible to the weaver, and as the backing ends are frequently of poorer material and thus break oftener, this is somewhat of an advantage. For the same reason, namely, that the backing ends are often weaker than the face ends, it is also an advantage to place the backing warp on the front harnesses, since the back harnesses are lifted higher during weaving, thus bringing more strain on the yarn drawn through them.

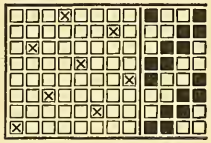
14. The method of making the drafts for a warp-backed fabric will be explained, taking Fig. 19 as an example. The first step is to make the harness draft. In drafting this design, the back warp will be placed on the front harnesses and consequently will be drafted first. Since in this example the backing weave is an 8-harness satin, it will require 8 harnesses. Proceed exactly as in single cloth, taking care, however, as this weave is arranged 1 face and 1 back, to

leave every other vertical row of squares on the design paper for drawing in the face warp. Next make the harness draft for the face weave, placing it above the draft for the back weave but on the vertical rows of squares reserved for the face warp. As the face of Fig. 19 is a 4-harness weave, there will be two repeats of the face drawing-in draft to one repeat of the back. The complete drawing-in draft obtained as explained above is shown in Fig. 23 (*a*), the back warp being drawn in on the front harnesses.

In making the chain draft, the same system as that explained in connection with single cloths is adopted; and

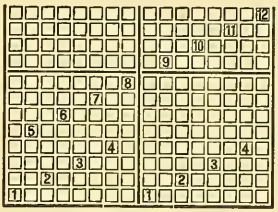


(*a*)

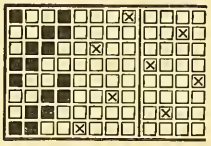


(*b*)

FIG. 23



(*a*)



(*b*)

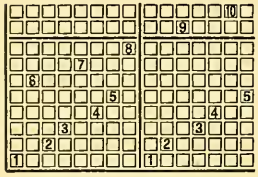
FIG. 24

since the warps have been separated and drawn in on separate harnesses, the face and back weaves will be separated in the chain draft. Fig. 23 (*b*) shows the chain draft for Fig. 19 drawn in according to the harness draft shown in Fig. 23 (*a*); the crosses show the picks on which the back-warp harnesses are raised.

If it were desired to draft Fig. 19 with the back warp drawn in on the back set of harnesses, the harness draft would be made as shown in Fig. 24 (*a*). When making the chain draft for Fig. 19 according to the harness draft shown in Fig. 24 (*a*), the same method is observed as with single cloth, which gives the draft shown in Fig. 24 (*b*).

15. When drafting warp-backed weaves that are arranged 2 face and 1 back, the same methods are employed as those previously explained except that 2 face ends are placed consecutively on the drawing-in draft in accordance with the design. The method of making this style of drawing-in draft is shown in Fig. 25 (*b*), which is the drawing-in draft for Fig. 25 (*a*). The chain draft for Fig. 25 (*a*) according to the drawing-in draft shown in Fig. 25 (*b*) is shown in Fig. 25 (*c*).

(*a*)



(*b*)

(*c*)

FIG. 25

EXAMPLES FOR PRACTICE

1. Back the $\frac{4}{2}$ regular twill with warp, arranging the ends 1 face and 1 back; tie each backing end perfectly.

2. Back the $\frac{4}{2}\frac{3}{3}$ regular twill with warp, arranging the ends 1 face and 1 back; tie the backing warp in 12-end satin order.

3. Make a design for a warp-backed fabric having the $\frac{3}{1}$ regular twill on the face and the 8-harness satin weave on the back, arranging the ends 1 face and 1 back; show harness and chain drafts with the back warp drawn in on the front harnesses.

4. Back the $\frac{4}{1}$ regular twill with warp, arranging the ends 1 face, 1 back, 1 face; tie the backing warp in 5-end satin order and show harness and chain drafts with the face warp drawn in on the front harnesses.

PIQUES AND BEDFORD CORDS

PIQUÉS

16. Although **piqués** cannot strictly be classed with either filling-backed or warp-backed cloths, they have features similar in many respects to both types. For example, a piqué cloth has a separate system of filling, known as the **wadding filling,** and in this respect resembles a filling-backed fabric. It also has a separate system of warp ends, in which respect it resembles warp-backed fabrics; but unlike warp-backed fabrics these backing ends in piqués are for the purpose of holding the wadding filling and also to cause ridges across the cloth, not to add any weight or warmth to the fabric.

In making a design for a piqué, the following points should be noted: (1) When placing the weave on design paper, the first step is to indicate the vertical rows of squares on which the face ends are to be placed and also the vertical rows of squares on which the backing ends are to be placed; this can be done by shading the vertical rows of squares representing the backing ends, as was done when making warp-backed designs. (2) The proportion of face ends to back ends in piqués is generally 2 face and 1 back; that is, every third end on the design paper will be a backing end. (3) The picks on which the wadding filling is to be inserted should be indicated in some way. (4) The proportion of face picks to wadding picks depends to a large extent on the kind of yarn to be used for the wadding; in case it is coarser than the yarn for the face picks, the proportion is generally 2 face to 1 wadding, although different proportions are used to suit different requirements. (5) In addition to the face

and wadding picks there are what are known as the **cutting picks**; these are the picks on which the backing ends are brought to the face for the purpose of pulling down the face cloth between the wadding picks, thus forming furrows across the cloth, and should be indicated on the design paper in some manner. (6) The number of picks between the cutting picks is determined by the design to be woven; however, if possible, there should be at least 2 picks of the face weave between the wadding picks and the cutting picks. (7) The face weave is placed on all the face ends, neglecting the backing ends and wadding picks entirely; this is done

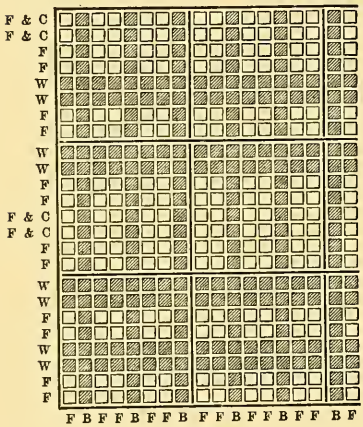


FIG. 26

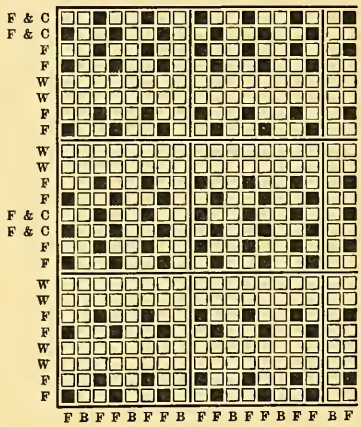


FIG. 27

in exactly the same manner as was explained with warp-backed fabrics. The face weave of piqués is generally the plain weave. (8) All the face ends are raised on the wadding picks. (9) All the backing ends are raised on the cutting picks.

17. Fig. 26 shows the design paper marked out for a piqué design occupying 18 ends and 24 picks. The shaded squares indicate those on which the backing warp and the wadding filling are to be placed. The ends and picks are also marked with the letters *F*, face; *B*, back; *W*, wadding; *F & C*, face and cutting. The next step in the formation

is the placing of the face weave on the squares that are not marked for back ends and wadding picks. Fig. 27 shows the design with the plain weave inserted for the face. The next step is to mark the design to show all the face warp ends raised on the wadding picks, since these are inserted so as to cause the face cloth to be pushed upwards between the cutting picks. The back warp must remain down on the wadding picks to bind the wadding picks to the fabric. The next step is to raise the backing ends on the cutting picks. This requires the backing ends to be raised on the eleventh and twelfth, also the twenty-third and twenty-fourth picks. The effect of this is to bind the backing ends to the fabric and pull down the face cloth to form a hollow place after a certain number of wadding picks have been inserted, in this case 4 picks, and after a certain amount of face cloth has been woven, in this case 6 picks.

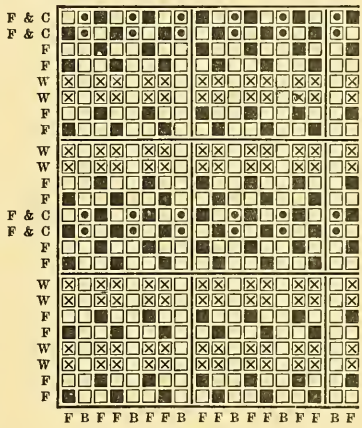


Fig. 28

Fig. 28 shows the design complete. The first 2 picks are plain, the backing ends being down and consequently not showing on the face at all. On the third and fourth picks, the wadding is inserted. While this is done all the face warp is raised, as shown by the crosses, and the back warp is down; consequently, the picks of wadding will lie in between these two series of yarns and will not show on the face, but being heavier than the face yarns will tend to raise the cloth constructed by the face weave. The next 4 picks are repetitions of the first 4 picks, and them come 2 more face picks. On the eleventh and twelfth picks, in addition to the plain weave of the face cloth, the backing warp is brought to the surface, as shown by the dots. These are the cutting picks. In weaving a piqué design, the backing warp is generally placed in a separate

beam that is weighted heavier than that containing the face warp, thus causing the backing warp to be under greater tension. When this backing warp is brought to the face, as it is under greater tension, it will of course tend to draw down the face yarns, thus causing a furrow between those parts of the cloth that contain the wadding picks.

The next 12 picks are but repetitions of the first 12 picks and consequently need no further explanation. Fig. 28 shows 6 repeats of the ends and 2 repeats of the picks, the design being complete on 3 ends and 12 picks. The design has been extended in this figure in order to show more clearly the construction of these weaves.

18. When studying the construction of a piqué design, it should be understood that the wadding picks do not show on the face of the cloth at any point, but simply lie between

Fig. 29

the face and back ends. Again, the backing ends do not show on the face of the cloth at all, except where they are raised for the purpose of pulling down the face cloth. Consequently, the face of a cloth woven with a design such as the one shown in Fig. 28 would be similar to plain cloth, with the exception of the raising of the cloth in ridges through the effect of the wadding picks, and also the floating of the back warp over 2 picks in certain parts of the cloth.

The position that the different ends and picks occupy when woven into cloth with this design is more clearly illustrated in Fig. 29, where a sectional view of 3 ends and 24 picks is shown. The heavy, dark line represents the backing end, while the other two lines running in the same direction show 2 face ends. The larger cross-sections marked *w* show the wadding picks, while the smaller cross-sections show the face picks. By referring to this figure it will be seen how the face picks interweaving with the face warp crowd over

the wadding picks, thus hiding them. It will also be seen how the backing end rising over the interlacings of the face filling and face warp draws them down, thus forming a furrow across the cloth.

DISSECTING A PIQUÉ

19. When dissecting fabrics of this type, the following points will be found to be of considerable assistance: (1) Find the proportion of face ends to the back ends by counting on the back of the cloth the number of backing ends per inch and then counting on the face of the cloth the number of face ends per inch. Suppose, for example, that there are found to be 30 backing ends and 60 face ends in an inch, then there are 2 face ends to every backing end and the pickout should be marked out in this manner. (2) Find the proportion of face picks to wadding picks. (3) Find the weave for the face cloth and place it on all the face ends, omitting the wadding picks. (4) Find the order of raising the back warp into the face; this can readily be done by taking a small part of the sample the wrong side up and pulling out the ends, one by one, instead of the picks, noting on the design paper whenever a back end is raised into the face cloth. (5) Raise all the face ends on the wadding picks.

20. In making the harness and chain drafts for a piqué design, the backing and face warps are drawn through separate sets of harnesses, as explained when dealing with cloths backed with warp. The backing warp is in most cases drawn through the back harnesses and the face warp through the front harnesses.

When piqué cloths are arranged 2 face to 1 back they are as a rule reeded 3 in a dent; that is, 2 face ends and 1 back end are drawn in each dent of the reed in such a manner that there will be 1 face end on each side of the back end in the dent. Piqués are high-pick cloths, the number of picks per inch being largely in excess of the number of ends per inch.

BEDFORD CORDS

21. Although Bedford cords have the same general appearance as piqués with the exception that the furrows run lengthwise of the cloth instead of across the cloth, their construction will be found to differ to a very large extent. Thus, in Bedford cords there will be found to be wadding ends instead of wadding picks. These wadding ends are held in the cloth by means of the same picks that form the face of the cloth instead of using backing picks, while 2 ends working plain throughout the entire length of the cloth form the furrow.

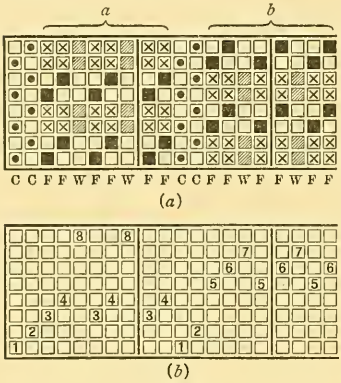


Fig. 30

Fig. 30 (*a*) shows one repeat of the ends and two repeats of the picks of a Bedford-cord design; the furrows lengthwise of the cloth, which are characteristic of Bedford cords, are formed by the first and second, also the eleventh and twelfth ends, which work plain throughout the cloth, while the weaves between them form the ridges. The parts of the design between the ends working plain are marked *a* and *b*. In section (*a*) the fifth and eighth ends, marked *W*, are the wadding ends. Dealing now only with the third, fourth, sixth, seventh, ninth, and tenth ends it will be noticed that they work plain on the first and second picks and are all raised on the third and fourth picks. This being one repeat of the design in its picks, the others are only repetitions of these first 4 picks. The effect of raising the ends in this manner is to cause the second and fifth picks and also the first and sixth to come together and thus produce a plain weave on the face of the cloth. It will also be noticed that on those picks on which all these ends are raised the wadding ends are also raised. The filling floating at the back will in this manner bind the wadding ends between the face

cloth and these picks of filling, not allowing the wadding ends to show on the face and yet holding them securely in position.

Referring now to section (*b*), it will be seen that this corresponds to section (*a*) with the exception that the position of the picks is reversed; that is, while in section (*a*) the face ends are working plain on the first and second picks, in section (*b*) they are all raised; and while in section (*a*) all the face ends are raised on the third and fourth picks, in section (*b*) they are working plain. Thus, the same picks, that are weaving plain to form the face cloth in section (*a*) are floating at the back to hold the wadding ends in section (*b*); and the reverse is also true.

The first, second, eleventh, and twelfth ends, which work plain throughout the cloth, will work tighter than the rest of the ends in the warp, and make the furrows between those parts of the cloth that contain the wadding ends.

DISSECTING A BEDFORD CORD

22. In dissecting a cloth of this character, the following points will be found of assistance: (1) Notice the ends that work plain throughout the weave and that form the furrows running lengthwise of the cloth; these are the ends that correspond to the first, second, eleventh, and twelfth ends in Fig. 30 (*a*). (2) Count the ends working plain on the face of the cloth in the raised portion between the furrows. It will be seen that in Fig. 30 (*a*) there are 6 ends. Then by looking at the back of the cloth the number of wadding ends can readily be determined, thus learning the proportion of face ends to wadding ends. (3) Arrange the ends on the design paper after the manner shown in Fig. 30 (*a*), taking care to have the wadding ends come between the face ends and also to have the face ends that are working plain in one section raised in the next, and vice versa.

It is not possible to pick out one of these cloths in the same manner as is done with cloths containing but one system of warp and one system of filling, but by having a

good general knowledge of their construction it is possible to learn the weave of any sample by simply studying the cloth by means of a pick glass. Bedford cords are high-sley goods and the number of ends per inch is always in excess of the number of picks per inch.

23. When making the drawing-in draft, the wadding ends are generally drawn through the back harnesses, while the face ends are drawn through the front harnesses. In reeding these cloths, each wadding end should be drawn into a dent with 2 or more face ends if possible. Fig. 30 (*b*) shows a drawing-in draft for Fig. 30 (*a*). In reeding the ends when drawn through the harnesses in this manner the best plan would be to draw 5 ends in a dent, commencing with the second end; that is, the second, third, fourth, fifth, and sixth ends would occupy one dent; the seventh, eighth, ninth, tenth, and eleventh, another; the twelfth, thirteenth, fourteenth, fifteenth, and sixteenth, another; and the seventeenth, eighteenth, nineteenth, twentieth, and first, another. This will bring each wadding end in a dent between 2 or more face ends.

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